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DC-7B AIRCRAFT SPRAY SYSTEM FOR LARGE-AREA INSECT CONTROL

DATA REPORT

BY

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NOVEMBER 1975

U.S. ARMY DUGWAY PROVING GROUND
Dugway, Utah 84022

EVALUATION PROGRAM
SPONSORED BY UNITED NATIONS
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Dugway Proving Ground conducted 10 trials of the DC-7B aircraft aerial spray system during October 1974. Two spray formulations, were disseminated and evaluated using three flow rates. Spray droplets were sampled vertically on towers and horizontally on ground surfaces. This report presents data on deposition and impaction sampling, droplet spectra, spray mass deposit, swath width, and mathematical modeling of the spray behavior.

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FOREWORD

On 30 January 1974, the Secretary of the Army authorized the Commander, US Army Dugway Proving Ground (DPG) to support a request from the Food and Agriculture Organization (FAO) of the United Nations for services, advice and facilities appropriate in the evaluation of a new technique using aerial spray for the control of insects, such as the tsetse fly.

Preliminary evaluation of the new DC-7B spray system at Barstow, California during 1972 (Reference 1) indicated that additional testing would be required to characterize the system before commitment to operational use.

A test plan involving 18 to 20 field trials (Table 2-1) at an estimated cost of $230,000 was prepared by DPG and submitted to the UN-FAO representative, Midair Inc. (Reference 2). Limitations in aircraft availability time and funds forced a reduction in scope. A modified program, with nine trials and less sampling, was developed in meetings with DPG and Midair personnel (Table 2-2).

This report presents the results of the reduced, nine-trial test program.

The UN-FAO representative, Midair Inc., was to provide a written discussion of operational use of the spray system and specific flow rates observed by their personnel during the trials. These critical data were not received, and thus the characterization of the spray system as defined by the five tasks (Par 1.3 of Reference 2) was not accomplished. However, this report does present the results of significant new developments in drop-spread-factor determination, analytical techniques, and mathematical prediction techniques.

The success of this project was attributed to cooperation of all personnel and organizations involved in the planning, execution, data analysis, and reporting. Special acknowledgement is due Dr. Lothar L. Salomon for his development of a new technique for determining drop-spread factors on sample cards. The technique was essential to analyzing drop sizes.

Mr. Thomas A. Griffths developed and validated the gas-chromatography method for analysis of Endosulfan.

The H.E. Cramer Co. made significant contributions in the test design and mathematical prediction modeling techniques used in the analysis.

FOREWORD REFERENCES

1. Randall, A.P. and B. Zylstra, Evaluation of a Modified Douglas DC-7B Aircraft and Spray System for Forest Insect Control, Project No. CC-001-2, Chemical Research Institute, Ottawa, Canada, October 1972.

2. Dugway Proving Ground, Utah, Characterization of DC-7B Aerial Spray System. USATECOM Project No. 5-CO-153-000-029, Test Plan (DPG-TP-C980A) by J.W. Barry, C.O. Eckard, P. Cheesman and H.E. Cramer, June 1974.

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CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

A need exists for an aerial spray system for depositing insecticides, pesticides, fertilizers, and seeds rapidly and efficiently over large forested and agricultural areas. The most urgent current problems involve insects affecting human health and food production on the continent of Africa. Spray systems now in use are capable of spraying small areas, in moderate winds, during daylight hours. Spray systems for fixed-wing aircraft are limited to small cropduster aircraft and WW2 bombers, which have limited capacity, speed and range. Helicopters are similarly limited, as well as by high cost of operation. Pressing world problems such as epidemics, famines and crop failures emphasize the need for improved methods of disseminating insecticides, agricultural chemical and seeds.

The Food and Agriculture Organization (FAO) of the United Nations is interested in a new technique of disseminating such materials from four-engined aircraft. The system is capable of spraying large areas and has a broad range of application rates. The long range and voluminous spray tanks equip the aircraft for longer periods of continuous spraying, with fewer landings for refilling and refueling. This technique promises to be very useful for proposed FAO projects of immediate concern, such as tsetse-fly control and pasture improvement in drought-afflicted West Africa.

FAO intends to launch a pilot project in a selected African country (when funds become available) to determine whether four-engined aircraft is more effective than ground spraying (or aerial spraying with smaller aircraft) for tsetse-fly control.

The economic impact of the tsetse fly is significant. The fly occurs throughout tropical Africa, mainly along lakeshores and riverbanks. Sleeping sickness, a disease transmitted by the fly, has severely limited the advancement of agriculture into areas otherwise ideal for crop and cattle production.

The tsetse fly is a member of the Glossinidae family, belonging to the Diptera order of insects. There are some 20 species, most of which attack man, with Glossina palpalis and G. motsitans being two of the most dreaded species and carriers of trypanosomiasis.

Trypanosomiasis or sleeping sickness is a fatal disease unless the victim receives early treatment. Both sexes of the tsetse fly carry trypanosomes, represented by several species of Trypanosoma sp., which are single-celled parasitic protozoans. The trypanosomes are transmitted by biting potential victims. The fly itself becomes infected by biting an infected host. Once infected, the fly can

transmit trypanosomes for 96 days to any susceptible person or animal it bites.

It is essential that before committing a particular spray system to operational use in the areas cited, characterization and evaluation tests be conducted with special reference to the droplet sizes and swath widths.

A preliminary evaluation of a spray system was conducted at Barstow, California, during 1972 (Reference 1). Results of this test indicated that additional tests would be required to characterize the spray system before the commitment to operational use.

A computerized navigational system for precise and accurate routing of the aircraft during swath spraying has been developed and found to be accurate within 60 feet. This system could provide a night-spraying capability at low altitudes.

Dugway Proving Ground (DPG) received a copy of a letter from the Secretary of the Army (Reference 2) to FAO, which addressed testing of a DC-7 spray system at DPG before adoption of the spray system for United Nations spray projects. A planning directive was received by DPG from HQ US Army Test and Evaluation Command (Reference 4).

DPG is the only North American test site capable of characterizing aerial spray systems generating aerosols and fine-droplet clouds of the magnitude described in References 3 and 1. DPG was established by the Department of the Army to test and evaluate military ordnance, including aerial spray systems. It has developed the technical expertise necessary to evaluate complex aerial spray systems. DPG has extensive test grids, meteorological instruments, sampling equipment, laboratories, and engineering facilities.

1.1.1 Large Aircraft Dispersal System Requirements

The rate of spray application must be variable from ultralow volume (ULV) to low volume (LV) to cover the various types of spray solutions as well as wettable powders and emulsifiable solutions, not only for insecticide applications but also for fungicidal and herbicidal use.

Due to the high operational costs of large multiengine aircraft, it is essential that the performance of the spray system be very reliable and the probability of failure be minimized. The only way that the probability of nonperformance can be minimized is to install a dual system complete with a dual power source. This installation would circumvent the inevitable failures of pump and power source. Both pump and power source should also have crossover features, and both have sufficient capacity to carry out the mission singularly.

In the interests of safety and also to ensure that imbalanced venting does not result in unequal loading, each tank should be individually vented externally. The pump should be in a sealed manifold so that any malfunction of the pump would not allow fluid into the aircraft. The tank compartment should be air-vented, and allowances for drainage to handle a major rupture should be incorporated. The flight compartments are sealed against fumes and spillage and equipped with emergency oxygen supplies.

All aircraft involved in application require some form of guidance. Large aircraft in large-scale programs requiring the ability to operate on a global scale with all the inherent problems of terrain, and support of logistics, need a complete, on-board, self-contained guidance system. With present technology, the only suitable system is an inertial navigation system programmed to carry out a spraying operation and also capable of carrying out its normal function in point-to-point navigation.

1.2 DESCRIPTION OF EQUIPMENT

1.2.1 Description of Aircraft

The Douglas DC-7B aircraft is a low-wing monoplane with full cantilever wing and empennage and semimonocoque fuselage, utilizing fully retractable tricycle-type landing gear (Figures 1 and 2).

The aircraft is powered by four Wright turbo compound, 18-cylinder, 3,350 cubic-inch-displacement, radial, air-cooled engines. The engines are equipped with Hamilton Standard Hydromatic, reversible, autofeathering, constant-speed, four-blade propellers. At sea level, the engines are rated at 3,250 bhp at 2,900 rpm. Each engine has an independent fuel system consisting of an engine-driven fuel pump, electrically driven booster pumps, fuel strainers, instruments, selector valves, crossfeed valves, dump valves and chutes. Fuel consumption at cruise is approximately 450 gallons per hour.

The original aircraft served as a commercial airliner with a carrying capacity of 77 passengers, a crew of five, a baggage compartment with a weight capacity of 13,840 pounds, and a structural maximum gross weight limit of 126,000 pounds.

Aircraft and engine specifications for Midair DC-7B in sprayer configuration with readily available 100-octane fuel as follows:

Maximum gross weight	113,800 pounds
Maximum landing gross weight	102,000 pounds
Maximum 0-fuel weight	97,200 pounds
Empty weight	68,030 pounds

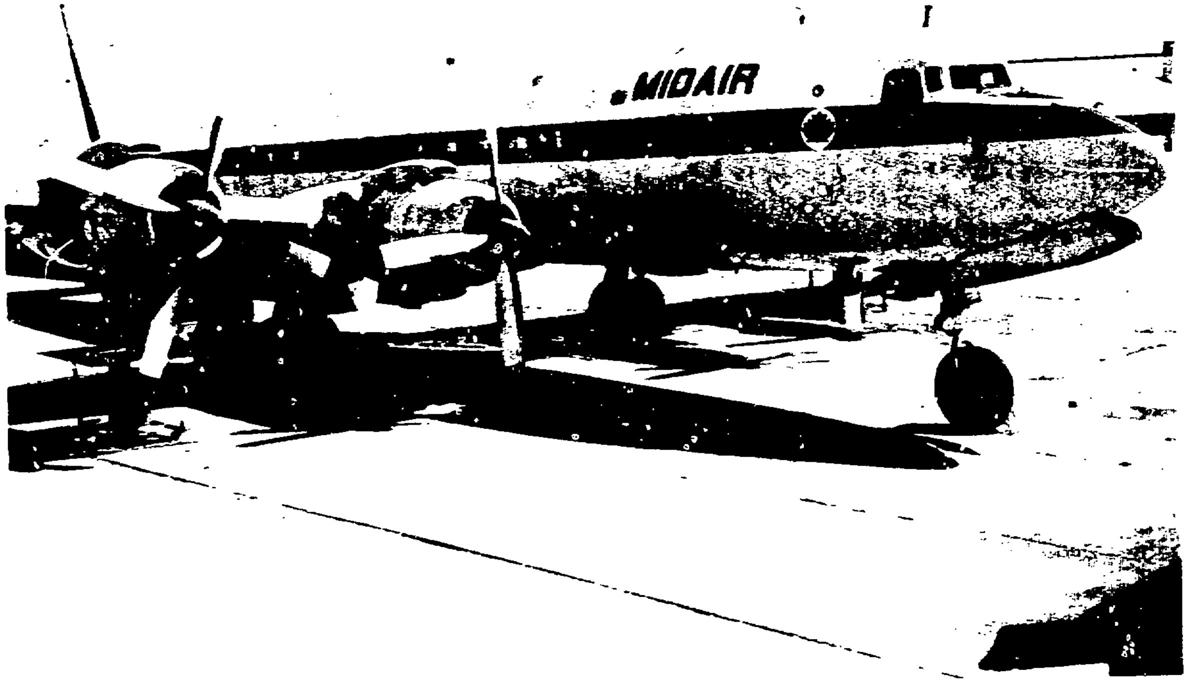

Figure 1. DC-7B Aircraft

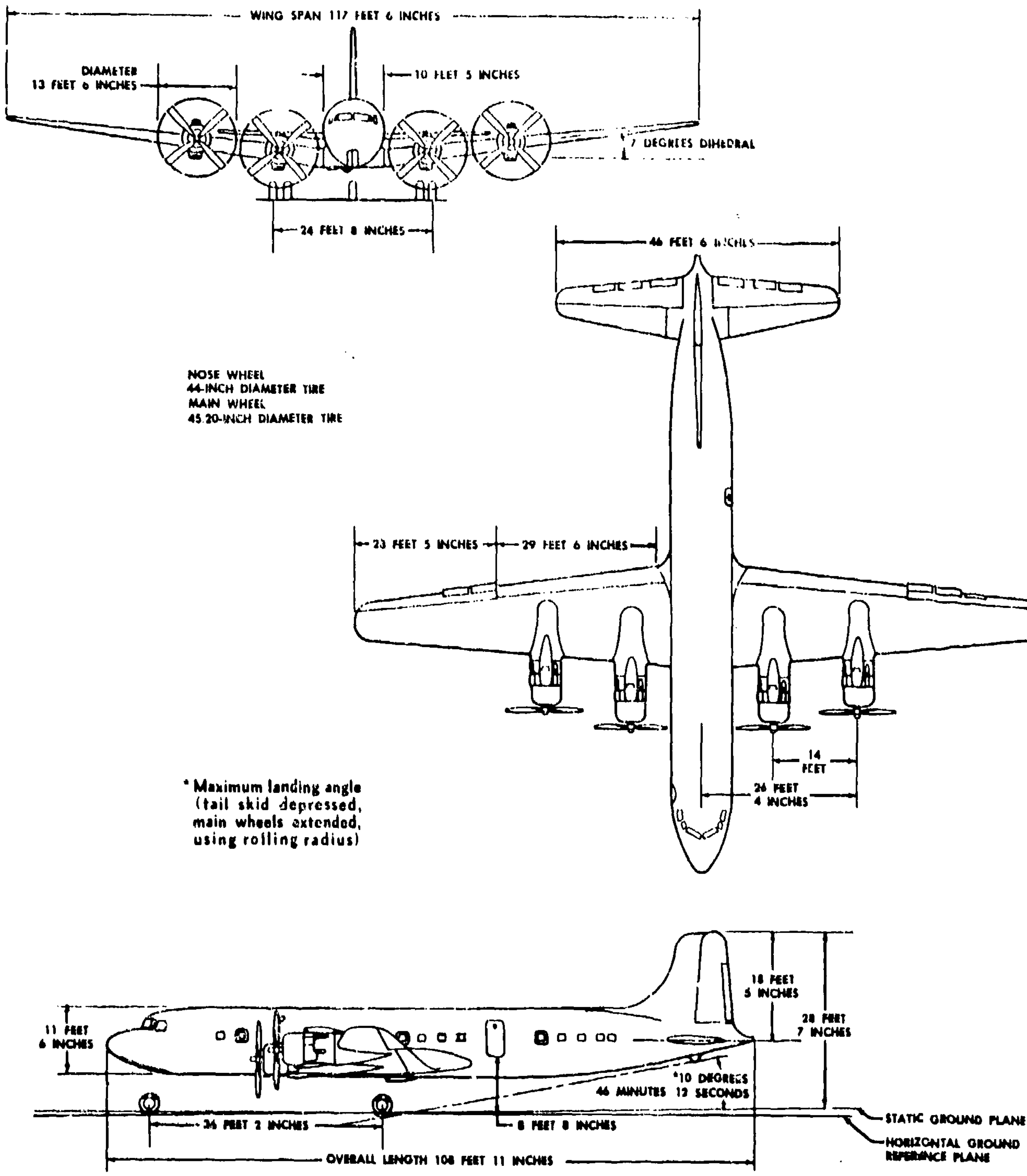

Figure 2. DC-7B Aircraft Dimensions

Operating weight, including crew and oil	70,295 pounds
Maximum payload	26,905 pounds
Maximum load in spray tanks	24,000 pounds
Maximum fuel capacity	4,512 US gallons
Fuel consumption	450 gallons per hour
Cruising speed	240 knots

A third electrically driven hydraulic system is capable of operating the spray-system valves for ground loading and for emergency operation of the valves in the event of both main hydraulic systems failing.

The inlet side of the spray system, including the tanks, underwent an FAA-witnessed pressure test of 50 psi with no leaks. The outlet side of the spray system underwent an FAA-witnessed pressure test of 100 psi with no leaks. Each of the eight tanks in the system is individually vented overboard. The system is pressure-loaded via two 3-inch-diameter camlock style quick-disconnect fittings under the belly of the aircraft. Dual electronic tank gauges with readouts are calibrated in tenths of tank, for both the spraymaster and the flight crew. The tanks are valved to prevent a load transfer due to aircraft altitude. The spray booms and their attachments are such that they can handle the full output flow from the pumps, and they are free from flutter and excessive vibration. The boom is equipped with adjustable shutoff-pressure checkvalves, which give an instantaneous clean shutoff. The spraymaster has an accurate display readout of the following parameters: boom pressure, flow from each spray pump, and pressure of each hydraulic system.

As well as meeting the pressure test, the components of the spray system are constructed of the following materials for chemical resistance: aluminum, stainless steel, Teflon, and chemical-resistant tubing with MCP and Teflon liners. Buna-N and Viton are utilized only in the case of static seals. Each boom has a cleanout port, and each pumping chamber has a drain to permit the system to be flushed without dismantling.

1.2.3 Description of Spray System

General. The system installed in a Douglas DC-7B type aircraft consists of eight 556-gallon tanks installed in two rows of four tanks in the main cabin area. These tanks are individually vented to the outside of the aircraft with a 3-inch-diameter vent line connected to a ram scoop. The tanks are connected in parallel pairs. The fluid level of each tank is measured by an electronic gauge connected to a panel-mounted display, one in the spray-master console and a duplicate in the copilot's roof-instrument panel. The display consists of eight rows of solid-state lights mounted in vertical position, 11 lights

in each row. When all lights are "ON", the tanks are full. As the level drops, the lights go out; this gauge gives instant reference to the aircraft load at all times. (See Figures 3, 4, 5 and 6.)

The full-span aluminum boom with a cross-sectional area of 8.1416 square inches is mounted above the trailing edge of each wing with a capacity for 150 outlets; outlets are reinforced 3/8-inch pipe-thread bosses spaced 8 inches apart. This allows the operator a variety of options permitting application ratios from less than 1 ounce per acre (73 ml per hectare) to 60 ounces per acre (4.38 liters per hectare) with a 3,000-foot (914.4-meter) swath width.

The pumping system consists of two submerged centrifugal anti-foaming pumps, hydraulically driven. Each pump is mounted in a sealed manifold in the after baggage compartment.

Tanks, pumps and booms are all connected through a valve manifold with hydraulically operated valves. The valve arrangement will allow any pair of tanks to be fed to either pump. The system under general operating conditions only requires one pump, and failure modes have been established to allow the aircraft to operate with both spray and hydraulic system failures.

The hose used to connect all systems is resistant to most known chemicals and acids, and all connections to tanks, pump, etc., are of the quick-disconnect type.

The system is loaded from two 3-inch quick-disconnect loading ports in the belly of the aircraft at the wing root.

Pump manifolds have dry-break drain fittings in the belly, which permit the insecticide to be completely drained from the aircraft.

A spraymaster control console and seat have been installed at the rear of the fuselage cabin area. The console is designed to allow the operator to regulate the application rate, to monitor the pressure and flows, and to instantly change from left or right system if required. Installed on the console is a separate oxygen system complete with smoke mask; also, microphone and telephone jacks for communications with forward crew. The microphone is operated by a footswitch. (See Figure 5)

1.2.4 Description of Hydraulic System

To provide an adequate source of hydraulic power to operate the dispersal pumps and valves, and to ensure a satisfactory backup system, hydraulic pumps were installed on the two outboard engines, each rated to operate the spray system by itself (25 gallons per minute at 3,000 psi). A 50-gallon reservoir is mounted on top of the forward end of number 6 spray tank; mounted on the reservoir is an electrically

(continued on page 12)

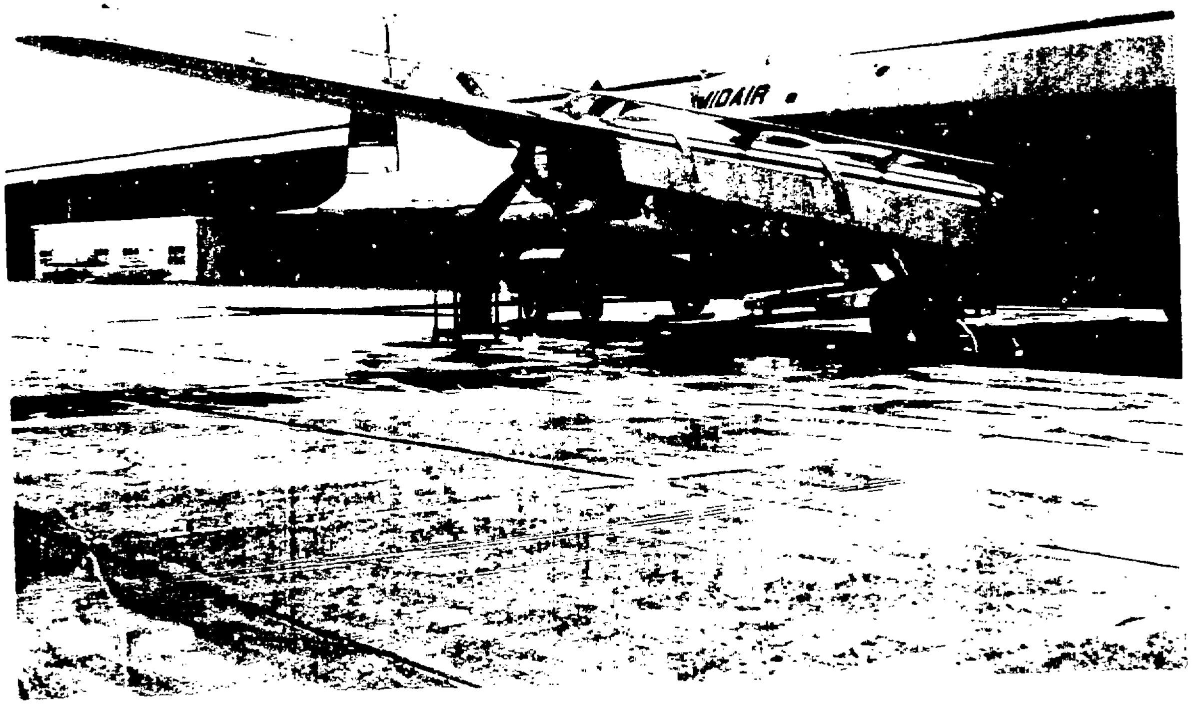

Figure 3. Spray Boom Mounted on DC-7B Aircraft

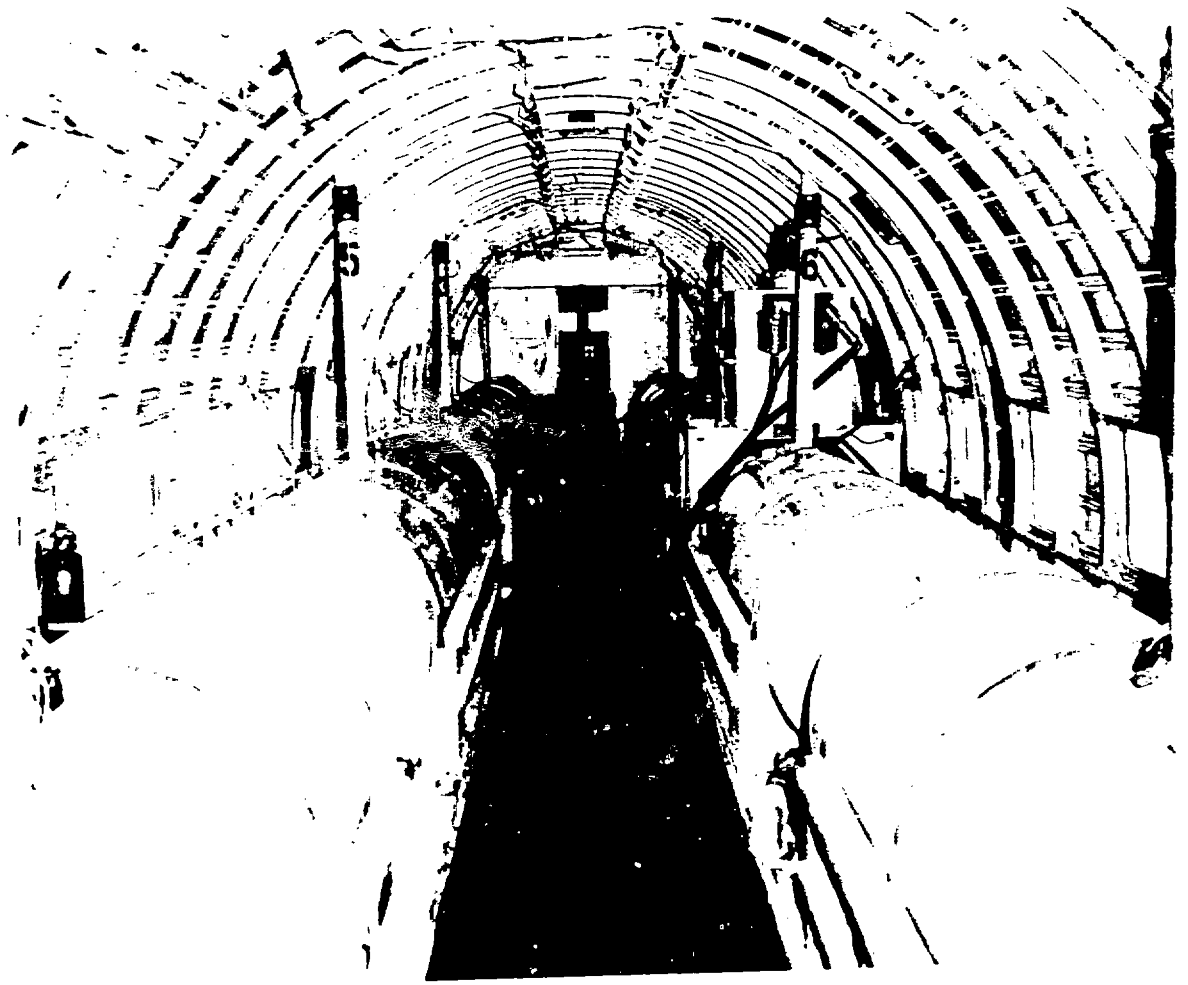

Figure 4. Spray Tanks Mounted in Main Cabin DC-7B Aircraft

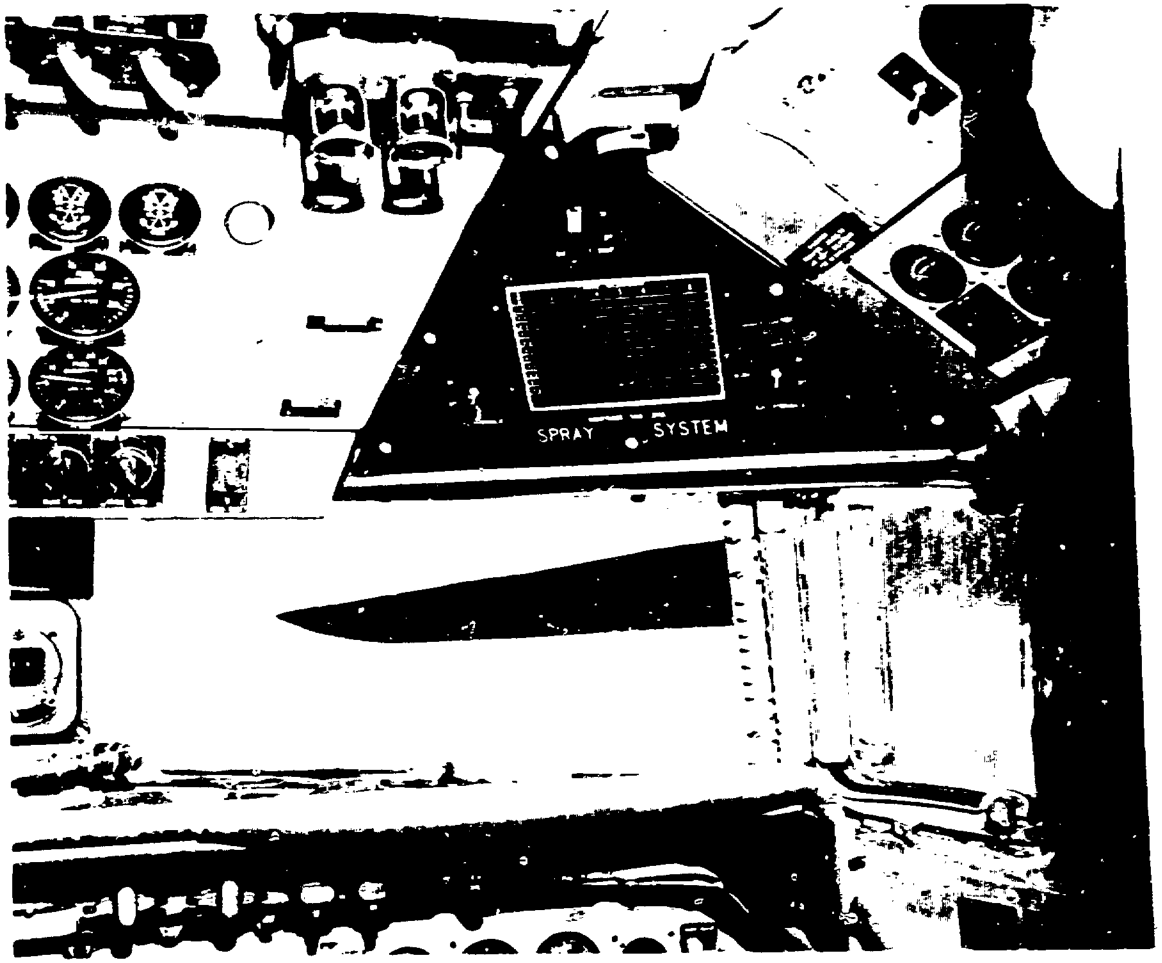

Figure 5. Panel Display for Spraymaster Monitoring of Spray Tank Pressure and Flow Rate

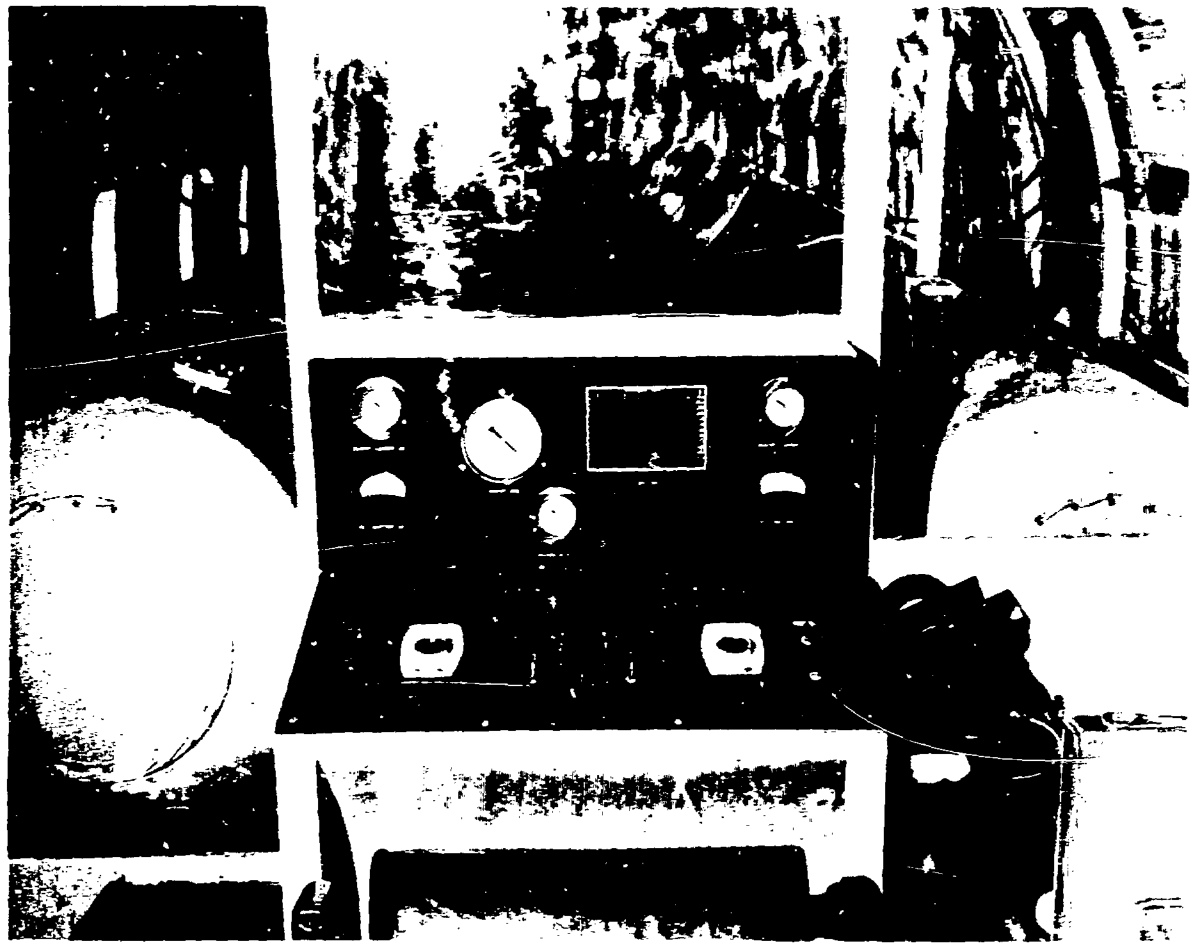

Figure 6. Duplicate Panel Display Mounted on Ceiling Above Co-Pilot Position

driven hydraulic pump, a source of hydraulic power for ground and emergency operations. Each pump has an independent inlet to ensure an adequate supply of hydraulic fluid should a failure occur. Also, the reservoir has a warning horn which sounds the instant the level falls below 60 percent of full capacity.

The valves, pressure reducers, regulators, etc., are mounted on a panel originally designed for the aircraft heating and air-conditioning unit.

A firewall cutoff valve is installed on both outboard engines and controlled from the command-pilot position. Also, the aircraft pilot has the control of switching on or off each system or operating the dump valves in an emergency.

1.3 RATIONALE

Experience with the DC-7B aerial spray system, as described in the 1972 report by Randall and Zylstra (Reference 1), shows that droplets emitted from the spray boom installed on the wing of the aircraft are quickly swept into the slipstream and wing-tip vortices. Immediately behind the aircraft, the combined vortex tubes containing the spray droplets have an overall horizontal dimension normal to the flight path and approximately equal to the wingspan (127 feet), and an estimated overall vertical dimension approximately one-third as large (40 feet). The rotational velocities within the vortices are thought to be initially about equal to the speed of the aircraft but decrease rapidly as the individual vortices expand and combine to form a conical spray plume extending for long distances behind the aircraft. Within a few minutes after the spray has been released from the aircraft, the spray plume attains an estimated lateral dimension normal to the flight path of about 2,000 feet (600 meters). For spray altitudes of 150 to 200 feet, it appears that the lower edge of the spray plume first touches the ground within 30 seconds to 1 minute after release. The rotational velocities in the portion of the spray plume that first touches the ground are not known, but existing theory and experimental knowledge indicate they are relatively small, with much higher rotational velocities expected near the center of the plume just below flight altitude.

It appears that the spray plume reaches approximate equilibrium with the air within 2 to 10 minutes after release, depending on wind speed and turbulence. Before this approximate equilibrium, the deposition of spray droplets is principally controlled by the decaying vortex circulations and the effects of the wind in transporting the vortex-dominated spray plume downwind from the flight line. Once approximate equilibrium has been attained, the deposition of spray droplets is principally determined by meteorological factors and the settling velocities of the spray droplets.

To achieve a satisfactory understanding of the swath width and deposition patterns of the DC-7B system requires a comprehensive field measurement program, which provides for detailed measurements of swath width, deposition patterns, initial drop-size distribution in the spray plume, downwind spray concentrations and deposition for various flow rates and under various meteorological conditions. In the design of the measurement program, it was important to recognize that there are two sets of time and space scales of interest. As pointed out above, the effective swath width and the deposition pattern within a few thousand feet of the flight path are principally controlled by the vortex circulations produced by the passage of the aircraft. These vortex circulations last only minutes after release. Documentation of the effects of these circulations required a relatively dense network of measurement points covering approximately 1 square mile and extending vertically to a minimum height of 300 feet.

Measurements made within this dense network must be supplemented by rapid-sequence photographs to obtain as complete details as possible on the growth of the spray plume and the properties of the plume during the first few minutes after release until approximate equilibrium is achieved. The second set of time and space scales of interest is identified with the history of the spray plume after approximate equilibrium has been achieved and the plume is transported downwind. For this purpose, the density of the measurement network must be significantly decreased and the areal extent of the network increased to cover maximum downwind travel distances of the order of 20 miles and maximum transport times of the order of a few hours.

In addition to providing documentation relative to swath width and deposition patterns, the measurement program must also provide the information required for developing and implementing mathematical models for predicting the behavior of the spray plume during the two stages of plume development mentioned above. For modeling the first stage, it is necessary to know as much as possible about the initial drop-size distribution, details of the vortex circulations and the growth of the spray plume associated with the expansion of the vortex tubes and the decay of the rotational velocities, which culminate in approximate equilibrium with the air. For modeling the second stage of plume behavior, it is necessary to know the properties of the spray plume (cloud dimensions, drop-size distribution and location in space) at approximate equilibrium. This information is used to establish the initial conditions for the second stage. Additionally, the wind speed, wind direction, air temperature, humidity, and turbulence must be known for the air mass in which the spray plume will be transported downwind. As a minimum, measurements are required of these meteorological parameters from the surface to 5,000 feet, taken near the flight line and at least one other distance along the downwind plume trajectory. Similar meteorological information is also required within the first 500 to 1,000 feet to model the first phase. The requisite meteorological

data are provided from tower measurements, pilot-balloon (PIBAL) soundings and rawinsonde soundings.

Acquisition of above spray and meteorological data and their use in conjunction with the mathematical prediction models facilitates the evaluation of the field data and provides an objective method for predicting the results of spray releases in other meteoeological and geographical regimes. It is believed that existing models were adequate for predicting the plume behavior during the second stage; however, modeling techniques for predicting plume behavior during the first stage will require additional testing and improved sampling techniques.

Sampling and assessing spray droplets less than 100 micrometers in diameter present technical challenges. The Midair system was designed to generate droplets less than 100 micrometers in diameter. These preliminary field trials involved the evaluation of measurement techniques to determine the procedures best suited for determining drop-size distribution, deposition patterns, and air concentrations of spray material at the various downwind distances. Therefore, to insure maximum accountancy of the spray material, a combination of deposition and impaction samplers were required, along with laboratory assessment techniques (including droplet counting and sizing and chemical analysis).

Four basic types of samplers were employed; the Printflex-card, rotorods (H- and U-shaped), filter paper wrapped on a 2.5-inch-diameter can, and an inert cylindrical sampler (pipe cleaner).

The Printflex-card is a horizontal deposition sampler, which provided data on droplet size distribution and mass deposition at the ground. The two inert aerosol samplers used were a 2.5-inch-diameter can wrapped with Printflex-card stock and a 2-mm-diameter pipe cleaner. The pipe cleaner sampler provided data on mass deposition of the cloud in the vertical plane near the release line. The wrapped can provided qualitative data on the droplet sizes in the aerosol cloud.

In one trial, fluorescent particles (FP) were added to the spray, and rotorod samplers equipped with both H- and U-type rods were placed downwind to provide qualitative data on downwind drift of small droplets.

The sampling and analytical techniques, as well as the cloud-prediction modeling techniques developed, proved highly effective in the analysis and interpretation of test data. However, additional trials and operational data are necessary before the test data can be applied to the characterization of the spray system.

CHAPTER 1. REFERENCES

1. Randall, A. P. and B. Zylstra, Evaluation of a Modified Douglas DC-7B Aircraft and Spray System for Forest Insect Control, Project No. CC-001-2, Chemical Research Institute, Ottawa, Canada, October 1972.

2. Letter, Department of the Army 30 January 1974, to Mr. Howard D. Cottam, North American Represenative Food and Agriculture Organization of the United States. (Copy attached.)

3. Letter, V2/372/2 World Health Organization, 9 November 1973, to Director General, Food and Agriculture Organization of the United Nations.

4. Letter, AMSTE-NB, Planning Directive for Customer Test of United Nations Aerial Spray Equipment, TECOM Project No. 5-CO-153-000-029, 19 March 1974. (Copy attached.)

(COPY)

DEPARTMENT OF THE ARMY
WASHINGTON, D.C. 20310

30 JAN 1974

Mr. Howard R. Cottam
North American Representative
Food and Agriculture Organization
of the United Nations
1325 C Street, Southwest
Washington, D. C. 20437

Dear Mr. Cottam:

The Secretary of Defense has asked that I reply to your letter of 14 January 1974 (Reference GP-4.1/AN-19) concerning testing of an aircraft, for tsetse control by aerial spraying, at Dugway Proving Ground.

The Army would be willing to cooperate in such a testing program under the following conditions:

a. The testing would be done at a time convenient for the Deseret Test Center, and not interfere with accomplishment of assigned tasks.

b. The Army will cooperate, by providing services, advice, and use of facilities as considered appropriate by the Commanding Officer, Deseret Test Center.

The Commanding Officer, Deseret Test Center, Dugway Proving Ground, Utah, has been provided a copy of this letter and is authorized to discuss the matters mentioned above with appropriate officials.

Yours sincerely,

(SIGNED) HOWARD H. CALLAWAY

Howard H. Callaway
Secretary of the Army

Copy furnished:
Commanding Officer, Dugway Proving Ground, Utah 84022

(END COPY)

(COPY)

DEPARTMENT OF THE ARMY Mr. Kadel/hcw/870-2172
HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

S: 22 Apr 74

AMSTE-NB

19 MAR 1974

SUBJECT: Planning Directive for Customer Test of UN Aerial Spray Equipment, TECOM Project NO. 5-CO-153-000-029

Commander
US Army Dugway Proving Ground
ATTN: STEDP-PC
Dugway, UT 84022

1. REFERENCES.

a. Letter, Food and Agriculture Organization (FAO) of the United Nations (UN), 14 January 1974, to Secretary of Defense, copy to USADPG.

b. Letter, Secretary of the Army, 30 January 1974, to Mr. Howard Cottam, FAO, copy to USADPG.

c. Letter, AMCRD-U, HQ, AMC, 1 March 1974, subject: Testing of Aerial Spray Equipment at USADPG (Incl 1).

2. BACKGROUND. Reference 1a requests Department of Defense cooperation in testing aerial spray equipment for control of the tsetse fly in Africa. Reference 1b advises that USADPG will provide such support as considered appropriate by Commander, USADPG.

3. DESCRIPTION OF MATERIEL. See inclosure to reference 1b.

4. TEST OBJECTIVES. Calibration of the system and determination of droplet size and swath characteristics.

5. RESPONSIBILITIES. USADPG will prepare the draft outline of a test plan for submission by COB 22 April 1974.

6. SPECIAL INSTRUCTIONS.

a. The cost of providing services, advice, and use of facilities as directed by US Army Materiel Command, reference 1c, will be obtained from DL14 funds.

19 MAR 1974

AMSTE-NB
SUBJECT: Planning Directive for Customer Test of UN Aerial Spray Equipment, TECOM Project NO. 5-CO-153-000-029

b. A cost estimate will be submitted to this Headquarters by COB 22 April 1974.

7. SAFETY. To be specified by sponsor.

8. TEST PLAN AND REPORT. To be specified by sponsor.

9. SECURITY. This project is unclassified.

FOR THE COMMANDER:

1 Incl
as

WILLIAM A SHREVE
Technical Director
NBC Mat Testing Directorate

(END COPY)

CHAPTER 2. SUMMARY

2.1 PURPOSE

The purpose of this test was to investigate the DC-7B spray system.

2.2 OBJECTIVE

The objective was to characterize the DC-7B spray system by the following:

a. Measurements of the spray drops at three flow rates (95, 227 and 871 liters per minute).

b. Characterization of the spray swath according to ground-deposition density, cloud shape and drop sizes for the three selected flow rates.

c. Determination of input parameters required by transport-diffusion models used to predict the atmospheric behavior of the spray cloud.

2.3 SCOPE

The original two-month project comprised 18 to 20 trials (Table 2-1. Fourteen trials were scheduled for the aerial-spray grid (ASG) at DPG to obtain data on: (1) the droplet spectra; (2) dissemination efficiency; (3) mass distribution within the vertical profile of the spray cloud; (4) input parameters for modeling the spray behavior; and (5) downwind drift of the spray cloud for each of three flow rates. Six trials were scheduled for the downwind grid (Target S) at DPG to obtain swath-width data for the three flow rates. All trials at the ASG and downwind grid were to be conducted in winds of 5 to 15 and 0 to 15 miles per hour at release height, respectively. Wind-direction limitations for the ASG and Target S trials were to have been normal to the release line ± 15 degrees and ± 30 degrees, respectively. Test methods were specified in Reference 1.

Midair, the UN FAO representative, requested the project be reduced to a 2-week test because of funding limitations and availability of the aircraft. The revised project (Table 2-2) consisted of six ASG trials and three Target S trials with one downwind-drift trial incorporated into the ASG matrix when favorable meteorological conditions were forecast. The meteorological limitations were identical to those imposed on the original test matrix.

(continued on page 23)

Table 2-1. Original Test Scope and Test Matrix

Phase	Applicable Task	Number of Trials	Application Rate Oz/A	Application Rate GPM	Test Grid	Samplers Position	Samplers Type	Samplers Number
1	1,2,4	3	3	25	ASG 300-Foot Tower	Tower every 2 meters vertically (Duplicates)	Printflex Card Filter Paper	92 92
						Upwind Array	Printflex Card Filter Paper Rotorod: H Shape U Shape	18 6 6 6
						Downwind Array	Printflex Card Filter Paper Rotorod: H Shape U Shape	54 30 30 30
		3	5	60	"	"	"	"
		3	20	230	"	"	"	"
2	1,3,4	3	20	230	Deposition	Dense Array	Printflex Card Rotorod: H Shape U Shape	821 53 53
						Downwind Extensions	Printflex Card Rotorod: H Shape U Shape	87 87 87
		3	5	60	Deposition	"	"	"

(continued)

Table 2-1. Original Test Scope and Test Matrix

3	1,4,5	3 to 5	20	230	ASG	Downwind Radials to 15 Miles	Printflex Card Filter Paper Rotorod: H Shape U Shape Inert Cylindrical Sampler	111 101 101 101 101
						Upwind Radial	Printflex Card Filter Paper Rotorod: H Shape U Shape Inert Cylindrical Sampler	18 6 6 6 6
						Tower every 2 meters vertically (Duplicates)	Printflex Card Filter Paper Inert Cylindrical Sampler	92 92 92

(concluded)

Table 2-2. Revised scope of testing

PHASE	Application Rate: Oz/Ac	Application Rate: GPM	Number of Trials	Test Grid	SAMPLERS: Position	SAMPLERS: Type	SAMPLERS: Number
1 Crosswind (Tower Flyby)	3 (20 mg/m^2)	25	2	ASG (300-ft tower)	Vertical	Inert Cylinder (Pipe Cleaner)	92
						Beer Can Cyl. Printflex Filterpaper	8 8
	5 (35 mg/m^2)	60	2		Hor. Upwind	Printflex	18
	20 (140 mg/m^2)	230	2		Hor. Downwind	Printflex	74
2[a] Inwind	3	25	1	Downwind Grid (3-mile sq. w/3dense lines normal to wind)	Horizontal	Printflex	315
	5	60	1				
	20	230	1				
3 Crosswind Dwd Drift	5	60	1[b]	ASG[c] (15-mile downwind w/300 ft tower)	Vertical	Same as phase 1	
					Hor. Upwind	Same as phase 1 plus Rotorods from tower to 15 miles downwind	70
						Printflex	114

[a] In this trial, the 30-meter meteorological sampling mast will be decorated.

[b] This trial will be conducted when prefrontal winds are available as part of Phase 1.

[c] Rows 390, 678, 966, West Downwind, 523 and Hwy 101 will be used with samplers spaced at 150-foot intervals.

Twelve trials were conducted during October 1974. Acceptable data were obtained in five trials, and partial data were obtained in five trials. Spray rates ranged from an estimated 0.07 to 4.38 liters per hectare. In the four Target S trials, the flight path was approximately parallel to the wind direction (the system malfunctioned in one trial). In seven of the eight ASG trials the flight path was approximately perpendicular to the mean wind direction. Requisite data for characterizing the vertical-profile mass distribution and dissemination efficiency were obtained in only three of the eight ASG trials because of a combination of inadequate wind speeds and a system malfunction. Meteorological limitations imposed in the test design were waived by the UN FAO representative because of the limited period of aircraft availability.

The flight altitude of the aircraft during the trials was approximately 50 meters above the ground. Two types of spray carrier were used. Duphar, a trade-name solvent of low volatility, was used in Trials 1-6 and 1-7. In the remaining ten trials, No. 2 fuel oil was used. Dupont oil red dye was added to both types of spray carrier as a tracer. Deposition measurements were principally obtained by placing Printflex-cards on the ground before each trial (see Figure 2-1). Spray droplets deposited on the cards produced red stains that were counted and sized by microscopic analysis. This information was used to calculate both the drop-size distribution and the total mass of spray material deposited on each Printflex-card. A summary of trials actually conducted is contained in Table 2-3.

(continued on page 26)

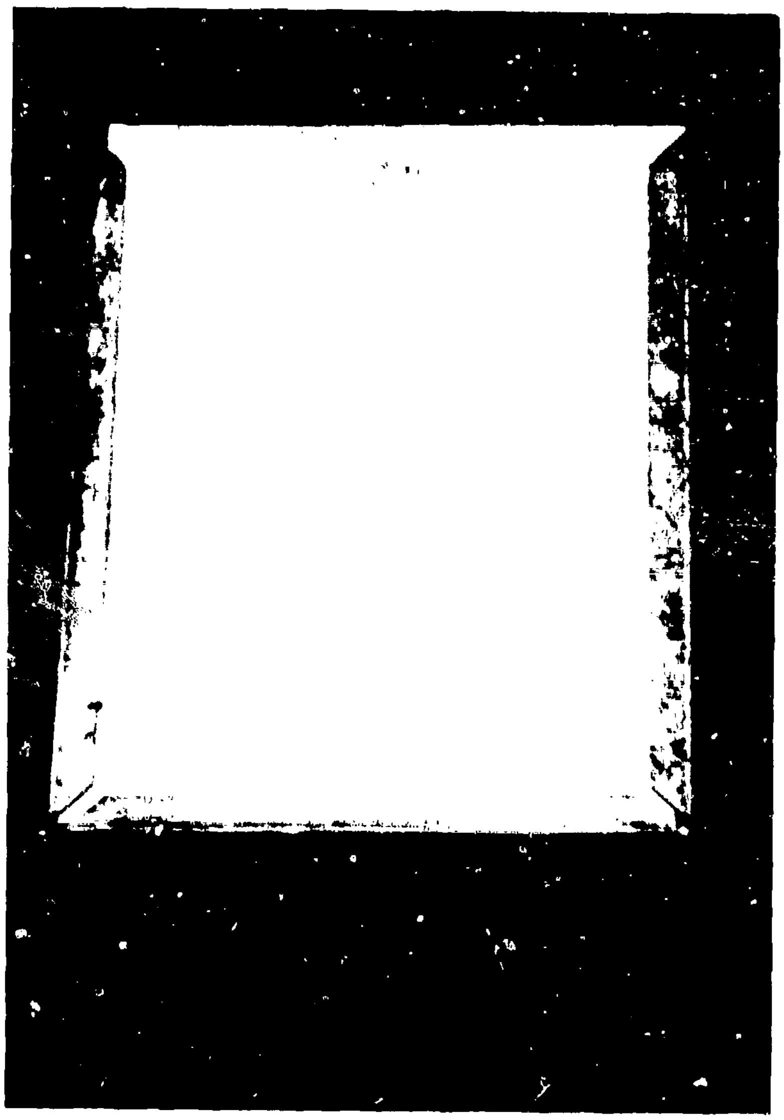

Figure 2-1. Printflex Card Sample

Table 2-3. Trials Conducted Under Revised Scope of UN Spray Trials

Trial Number	Date (1974)	Spray[a] Material	Programmed Application Rate gal/min	1/min	oz/acre	Flight Direction	Test Grid
1-1[b]	4 Oct	Fuel Oil	230	871	20	In Wind	ASG
1-1R[b,c]	8 Oct	Fuel Oil	230	871	20	In Wind	"
1-2[b]	8 Oct	Fuel Oil	230	871	20	In Wind	"
1-3[b]	15 Oct	Fuel Oil	230	871	20	In Wind	"
1-4[b]	15 Oct	Fuel Oil	25	95	2	In Wind	"
1-5	17 Oct	Fuel Oil[d]	60	227	5	Across Wind	"
1-6	17 Oct	Duphar	60	227	5	Across Wind	"
1-7	16 Oct	Duphar	25	95	2	Across Wind	"
2-1	9 Oct	Fuel Oil	230	871	20	In Wind	Target S
2-2[c]	9 Oct	Fuel Oil	60	227	5	In Wind	"
2-2R	10 Oct	Fuel Oil	60	227	5	In Wind	"
2-3	10 Oct	Fuel Oil	25	95	2	In Wind	"

[a] The spray materials were dyed with C1258 oil red dye.
[b] Requisite data on ASG sampling tower not obtained because of inadequate wind speed.
[c] Spray system malfunctioned (no data obtained)
[d] A small quantity of Endosulfan and fluorescent particles (FP) were mixed with the dyed fuel oil in this trial.

2.4 METHODS

A detailed description of the test-design concept, field test methods, data acquisition, and associated physical and chemical assessment techniques is presented in Chapter 3 and Appendix A. Methodology unique to this test is summarized below:

2.4.1 Spray Formulation and Tracer Materials

Characterization of this aerial spray system required the use of a combination of tracer materials (C1258 red dye, fluorescent particles and the chemical Endosulfan) and sampling methods.

a. C1258 red dye was used as a tracer in Number 2 fuel oil and Duphar to permit semiquantitative assessment of (1) mass deposition and droplet distribution at ground level from the release line to 5 miles downwind; and (2) the vertical distribution of the spray.

b. The system characterization was upgraded by using (1) Endosulfan to lower the mass detection limit for assessment of the dissemination efficiency of the system, and (2) fluorescent particles to permit detection of the downwind drift of the spray cloud to beyond 10 kilometers.

c. Selected physical properties of the two materials were measured to provide input parameters for mathematical modeling and safety information for spray operations.

d. The drop-stain relationship of the two materials collected on Printflex-card samplers was determined using laboratory techniques.

2.4.2 Sampling

a. Printflex-card samplers were used to measure spray deposition on the ground. The droplet size distribution was evaluated using three methods to estimate volume mean diameter, mass median diameter and deposition density for the spray patterns. Characterization of the area covered by deposition densities of interest were developed from these data.

b. A 98-meter vertical sampling tower equipped with impaction samplers was used to (1) obtain data on the mass distribution within the spray cloud from 0 to 92 meters above terrain, (2) to obtain data required to estimate the amount of material available for downwind transport or the dissemination efficiency of the system.

c. Rotorod samplers were used to collect fluorescent particles dispersed in the spray out to a distance of 10 kilometers. These data were used to characterize cloud intensity at long distances downwind and to provide empirical data for comparing model estimates.

2.4.3 Meteorological

Wind speed, wind direction, temperature gradient and the vertical components of wind direction were measured on 98- and 32-meter meterological towers. Surface observations and pilot-balloon (PIBAL) measurements were taken in the vicinity of the release line. These data were used to characterize the meteorological conditions associated with each trial and to develop input parameters for mathematical models.

2.4.4 Photographic

Mitchell cinetheodolites and 35-mm multidata fixed cameras were used to obtain data on the length of the spray release line, and the height, speed and heading of the aircraft during dissemination. These data were used in the dissemination efficiency estimates and to develop input parameters for the transport model.

2.5 RESULTS

2.5.1 Spray Formulations

a. In seven trials, the No. 2 fuel oil contained 0.49 ± 0.09 percent of C1258 red dye. In two trials the Duphar carrier contained 0.435 ± 0.05 percent of DuPont oil red (C1258) dye. In one trial, the fuel oil contained 1 percent Endosulfan, 0.5 percent C1258 dye and 1 percent fluorescent particles

b. The selected physical properties measured for the fuel oil and Duphar used in the test are given below:

Physical Property	Fuel Oil	Duphar
Density (gm/ml) at 20° C	0.847	0.87
Flash Point (°C)	38	111
Kinematic Viscosity (C_s) at 25° C	4.3	8.3
Evaporation Loss (% per hour)		
11° C	0.24	2.56×10^{-5}
24.4° C	0.21	9.78×10^{-3}

2.5.2 Chemical Analysis

a. The lower detection limit for Endosulfan using the gas chromatography method developed at DPG was 0.01 microgram per milliliter or 0.2 microgram per sample. The detection range was 0.01 to 5.0 micrograms per milliliter. The extraction efficiency for Endosulfan in n-heptane spiked with Aldrin (used as an internal standard) and 0.1 N sulfuric acid for a concentration range of 0.1 to 1.0 microgram per milliliter was characterized by the following expression:

$$y = 1.03 - 0.12\ X$$

where:

y = the reciprocal of the proportion of Endosulfan extracted (correction factor)

1.03 = intercept

X = log of Endosulfan concentration

b. The lower detection limit for C1258 dye in fuel oil using ultraviolet spectrography and Duphar was 0.3 microgram per milliliter over a nominal concentration range of 0.5 to 2.5 micrograms per milliliter. The average sensitivity of the analysis was 0.34 absorbance unit per microgram per milliliter.

2.5.3 Dissemination Efficiency Estimates

Dissemination efficiency was estimated in five fly-by trials. The estimates for Trials 1-2 and 1-3 are low because the vertical extent of the spray cloud was not contained by the sampling tower. The dissemination efficiency estimates for the Duphar trials 1-6 and 1-7 were twice as large as the good fuel oil trial (Trial 1-5). It is suspected this observation was caused by loss of fuel oil by evaporation. The estimated efficiencies are suspect, because the actual flow rates (source strength per unit length of the dissemination line) are unknown. The effective source strength and dissemination efficiencies assume the programmed flow rates to be correct but cannot be verified. However, the vertical recoveries obtained on Trials 1-5, 1-6 and 1-7 indicate the programmed flow rates of 60, 60 and 25 gallons per minute were probably correct. The dissemination efficiences, average meteorological conditions and aircraft operational parameters are summarized in Table 2-4 and 2-5.

2.5 4 Meteorological

Table 2-6 is a summary of the meteorological parameters for this test.

2.5.5 Swath Widths

A summary of the swath widths based on selected deposition density (mass) levels of 4, 12, 36, and 108 milligrams per square meter is given in Table 2-7. The width of the swath for areas receiving more than 10,000, 30,000, 90,000 and 270,000 drops per square meter with diameters less than 75 micrometers are also tabulated. These data should not be used to imply swath widths for either material or differences in the coverage for the two materials, since the programmed flow rates have not been verified and the sample size is inadequate to reflect a reliable indication of expected performance.

(continued on page 34)

Table 2- 4. Operational, Estimated Dissemination Efficiency and Horizontal Recovery Data for Fly-By Trials

Trial	Aircraft Ground Speed (knots)	True Aircraft Heading (°)	Flow[a] Rate (l/min)	Spray Release Height (m)	Length Spray Line (m)	True Wind Direction (°)	Wind Speed (m/sec)	Average[b] Dissemination Efficiency (%)	Horizontal[c] Recovery (%)
1-2	216	225	871	55	7,400	130	1.1	18.5	2
1-3	216	225	871	46	7,400	170	1.2	32.0	ND
1-5	216	225	227	52	14,080	330	3.0	50.2	11
1-6	216	225	227	46	7,376	300	1.0	92.7	76
1-7	216	225	95	40	7,488	305	1.8	105.2	47

[a] The actual flow rate is unknown; the test sponsor did not submit these data to DPG.
[b] Estimates were made using sampling data collected on two sides of the vertical sampling tower. Estimates for Trials 1-1, 1-1R, and 1-4 could not be made because of inadequate sampling data and spray system malfunctions.
[c] These data are based on assumed flow rates.
ND = No data.

Table 2.5. *Summary of Dissemination Characteristics Data for UN Trials*

Trial	Type of Solvent	Programmed Application Rate of Spray Formulation[a] (gal/min)	(oz/Acre)	Dye Concentration (g/ℓ)	Endosulfan Concentration (g/ℓ)	Source Strength: Formulation (g/m)	Source Strength: Dye or Endosulfan (g/m)	Recovery: Horizontal[b] (%)	Recovery: Vertical (%)	Drop Spectra: VMD (μm)	Drop Spectra: NMD (μm)
1-1	Fuel Oil	230	20	c	c	110.0	c	11	d	89	37
1-2	Fuel Oil	230	20	5.0	c	110.0	0.649	2	d	56	32
2-1	Fuel Oil	230	20	c	c	110.0	c	1	d	51	31
2-2R	Fuel Oil	60	5	c	c	28.7	c	11	d	58	36
2-3	Fuel Oil	25	2	c	c	12.0	c	11	d	51	32
1-3	Fuel Oil	230	20	4.8	c	110.0	0.623	d	d	61	36
1-4	Fuel Oil	25	2	c	c	12.0	c	21	d	59	33
1-7	Duphar	25	2	4.4	c	12.3	0.0621	47	105.2	63	47
1-6	Duphar	60	5	4.3	c	29.5	0.146	76	92.7	71	46
1-5	Fuel Oil	60	5	c	8.9	28.7	0.302	11	50.1	56	33

[a]See Table 3-1

[b]Based on deposition of spray formulation

[c]No assay

[d]Wind direction invalidated vertical or horizontal recovery

Table 2-6. Summary of Meteorological Parameters

Parameter	Trial Number									
	1-1	1-2	1-3	1-4	1-5	1-6	1-7	2-1	2-2R	2-3
Date	Oct 4 1974	Oct 8 1974	Oct 15 1974	Oct 15 1974	Oct 17 1974	Oct 17 1974	Oct 16 1974	Oct 9 1974	Oct 10 1974	Oct 10 1974
Release Time (MST)	1406	1320	1254	1037	1249	0953	1434	1055	1048	1247
Sunrise-Sunset (MST)	0631-1809	0635-1803	0642-1752	0642-1752	0644-1749	0644-1749	0643-1751	0636-1801	0637-1800	0637-1800
Ground Conditions	Moist	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Weather Conditions	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Cloudiness (10ths)	10	10	10	10	0	0	10	1	2	5
H_m[a] (m)	ND	ND	ND	ND	850	150	400	800	350	500
Wind Direction (deg)	Var.	Var.	Var.	Var.	330	300	305	162	315	320
$\bar{\mu}$[b] (m sec^{-1})	1.0	1.5	1.7	1.0	3.0	1.0	1.8	6.1	4.0	4.2
ΔT[c] (0.5-96m) (^oC)	-1.6	-	-2.1	-1.8	-2.4	-2.3	-2.4	-3.2	-3.6	-3.4
SR[d] (0.5-96m) (^oC sec^2 m^{-2})	-1.6	-	-.73	-1.8	-.27	-2.3	-.74	-.08	-.23	-.19
σ_A[e] {2.5} (deg)					10	5	10	ND	5	5
σ_E[f] {2.5} (deg)					10	5	10	ND	5	3
$\bar{T}$[g] (^oC)	16.7	21.0	21.9	17.6	23.0	17.7	24.5	18.9	16.6	19.4
Relative Humidity (%)	49	23	21	28	20	29	21	45	48	34

[a]Height of mixing layer.

[b]Mean wind speed.

[c]Vertical temperature gradient.

[d]Stability ratio = SR (96 m to 0.5 m) = $(T_{96}-T_{0.5})/(\bar{u})^2$.

[e]Standard deviation of wind azimuth.

[f]Standard deviation of vertical component of wind direction.

[g]Mean temperature.

Table 2-7. Summary of Swath Widths

Trial	Flow Rate (l/min)	Direction of Flight	Swath Width (m) for the Indicated Deposition Densities (mg/m^2)				Swath Width (m) for Areas Within the Pattern Receiving the Indicated Number of Droplets Having Diameters less than 73 Micrometers			
			4	12	36	108	10,000	30,000	90,000	270,000
1-1	871	In Wind	273	185	89	23	465	319	205	145
1-2	871	In Wind	176	23	0	0	521	394	203	45
1-3	871	In Wind	297	191	114	0	>1,009	726	329	187
2-1	871	In Wind	0	0	0	0	736	350	19	0
2-2R	227	In Wind	211	41	0	0	1,336	705	163	20
1-5	227	Across Wind	179	52	0	0	660	422	175	84
1-6*	227	Across Wind	1,318	290	120	14	>1,568	>1,568	478	138
1-4	95	In Wind	111	59	0	0	1,199	440	117	29
1-7*	95	Across wind	181	62	0	0	469	208	86	32
2-3	95	In Wind	89	0	0	0	437	268	142	49

*Duphar used as carrier.

2.5.6 Droplet Spectra

The volume median diameter (vmd) and number mean diameter (nmd) for each trial were estimated using the techniques described in Appendix A; the values are tabulated in Table 4-5. The vmd and nmd for the two Duphar trials (Trials 1-6 and 1-7) were 65.5 + 3.5 micrometers and 45.5 ± 2.1 micrometers, respectively. The vmd range for the eight trials using fuel oil ranged from 50 to 71 micrometers. The mean vmd was 57.1 ± 6.47 micrometers. The nmd range for the fuel oil sprays was 31 to 57 micrometers, with a mean of 36.0 ± 8.62 micrometers. The cumulative percent of mass associated with the range of droplets measured in each trial in which the programmed flow rate was 871, 227 and 95 liters per minute (230, 60 and 25 gallons per minute) are given in Figures 2-2, 2-3, and 2-4, respectively. The cumulative numerical distribution for the range of droplet sizes measured in trials with flow rates of 871, 227 and 95 liters per minute are given in Figures 2-5, 2-6, and 2-7. These data were used to generate the droplet data inputs, i.e. the settling velocity (V_{si}) and the fraction of mass (f_i) for each mean droplet diameter, Table 5-2.

2.5.7 Mathematical Model of DC-7B Spray System

The data obtained from five acceptable trials (Trials 1-5, 1-6, 1-7, 2-2R and 2-3) were used to develop the input parameters for a mathematical deposition model by H.E. Cramer, K.R. Dumbauld, et al. The model was used to estimate the axial deposition densities of the spray pattern as a function of downwind distance. The axial deposition densities right and left of the flight path were also estimated. The model and actual values were comparable, indicating the model is valid. In this analysis, the estimates of axial deposition density were restricted to a downwind distance of 10 kilometers.[1] No attempt was made to estimate deposition density directly below the flight path. Such estimates would require detailed knowledge of the trailing vortices and the interaction of the vortex system with the spray droplets and the atmosphere during the first 60 to 100 seconds after discharge of the spray. The general effect of wingtip vortices on the shape of the spray cloud was also investigated. The lateral source dimension of the spray cloud σ_{yo} was estimated as 20 meters (corresponding to a cloud diameter of 84 meters or three wingspans of the aircraft).

The results achieved with this model strongly imply that the downwind drift of spray clouds can be estimated using a modified form of the generalized concentration-dosage model for elevated line-source releases available at DPG. The model development and results are detailed in Chapter 5.

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[1]Evidence of spray cloud drift 10 kilometers downwind of the release line was verified by FPs collected on rotorod samples in Trial 1-5. These data are contained in Appendix B.

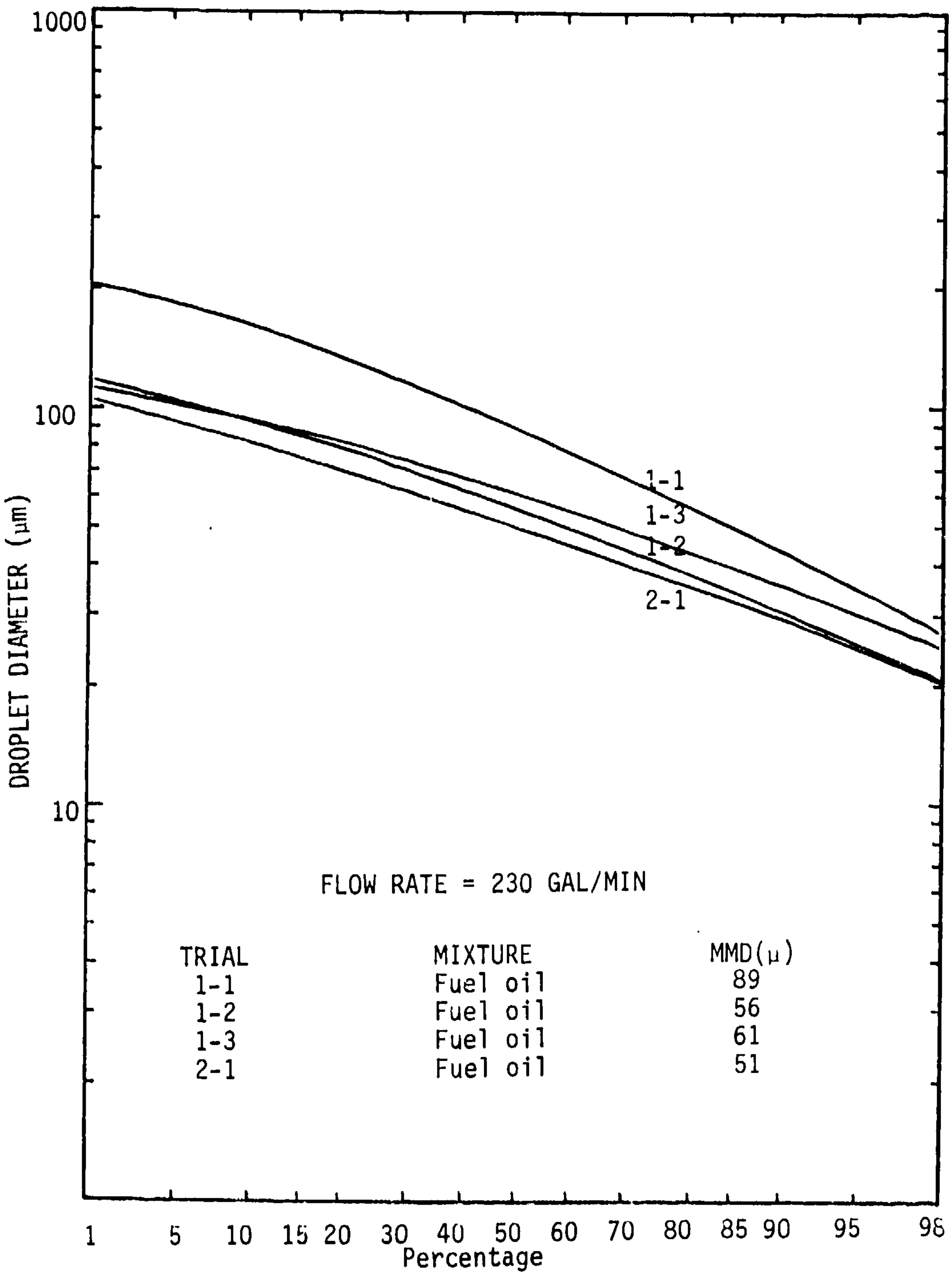

Figure 2-2 Cumulative Mass Distribution of Droplets as a function of Droplet-Diameter

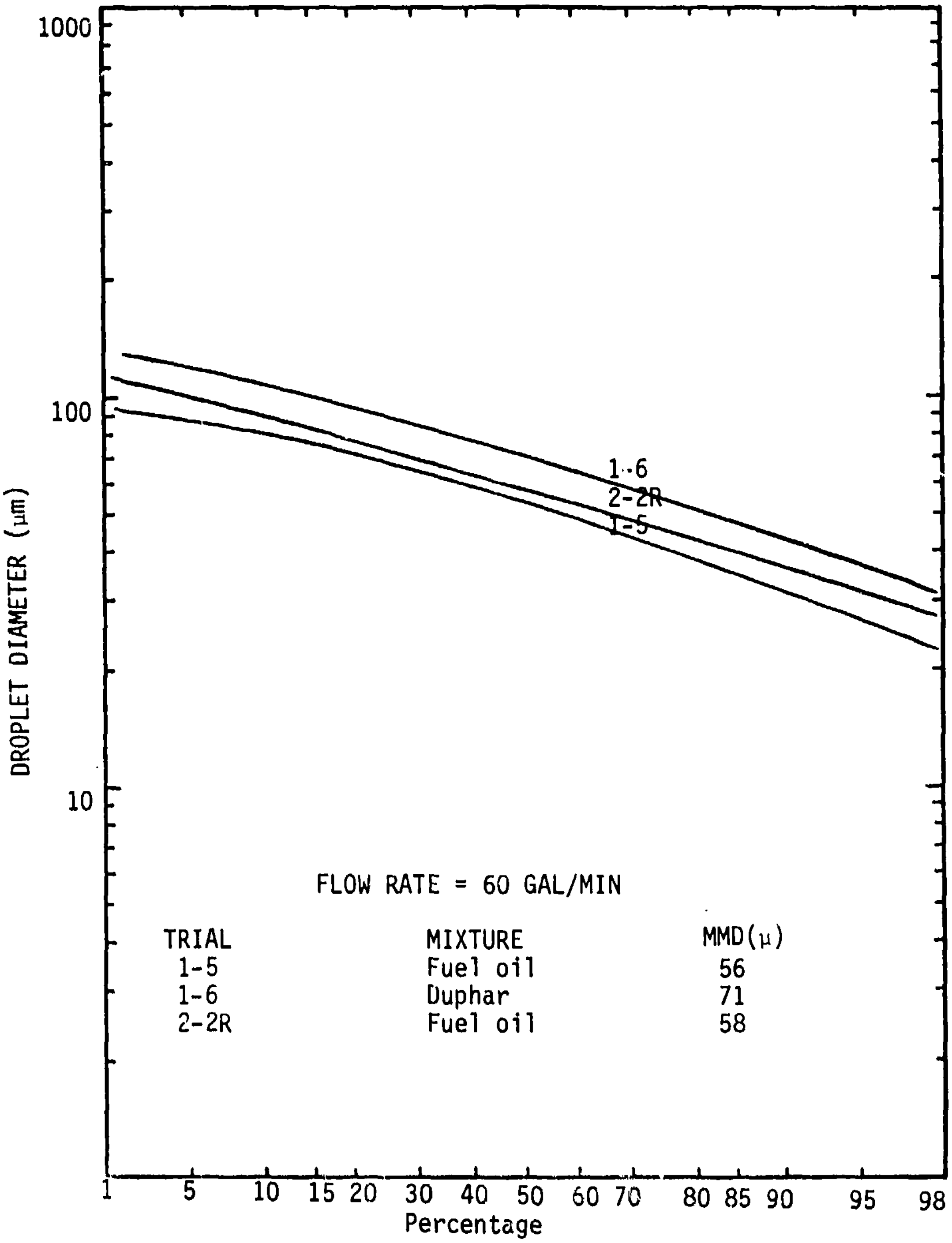

Figure 2-3 Cumulative Mass Distribution of Droplets as a function of Droplet-Diameter

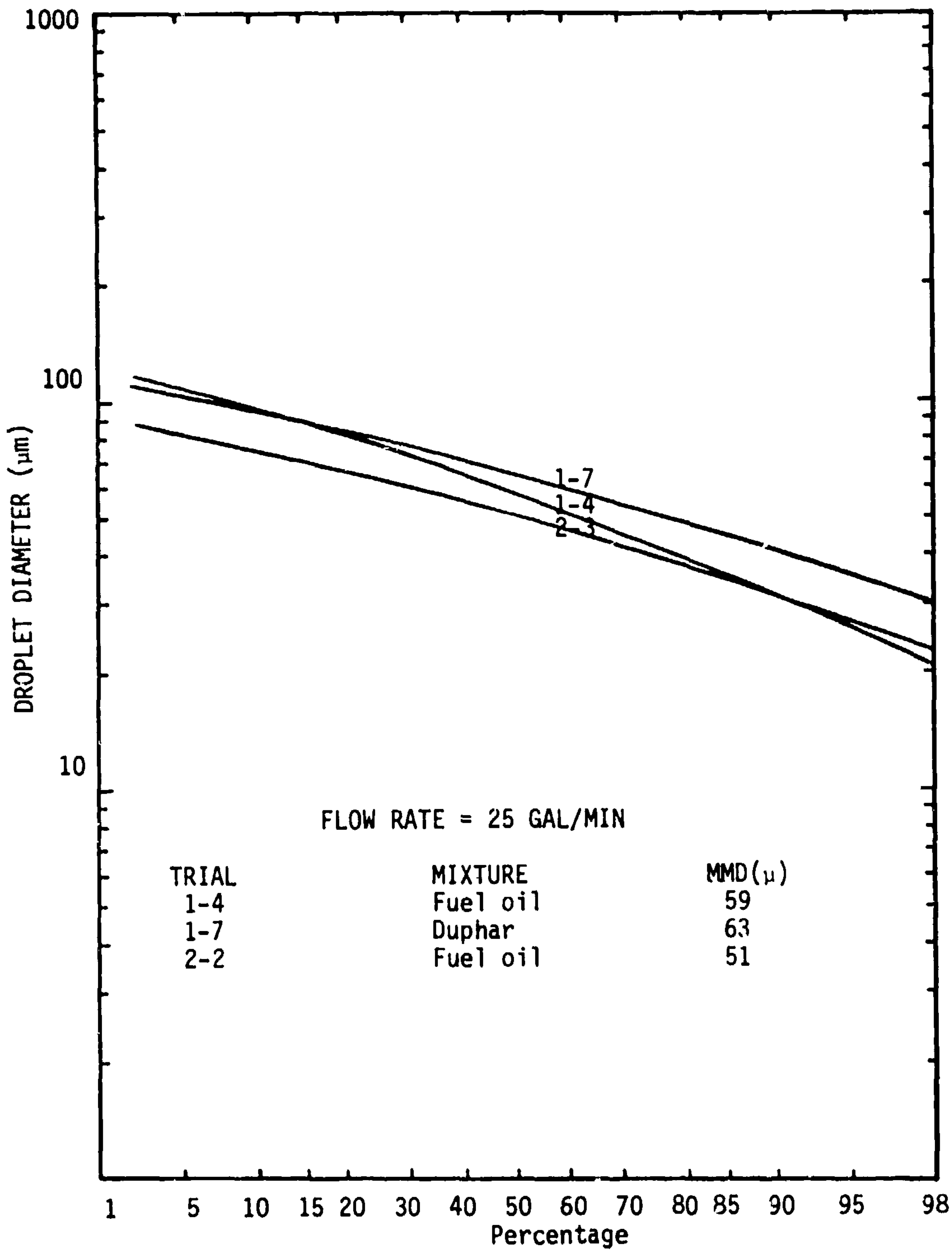

Figure 2-4 Cumulative Mass Distribution of Droplets as a function of Droplet-Diameter

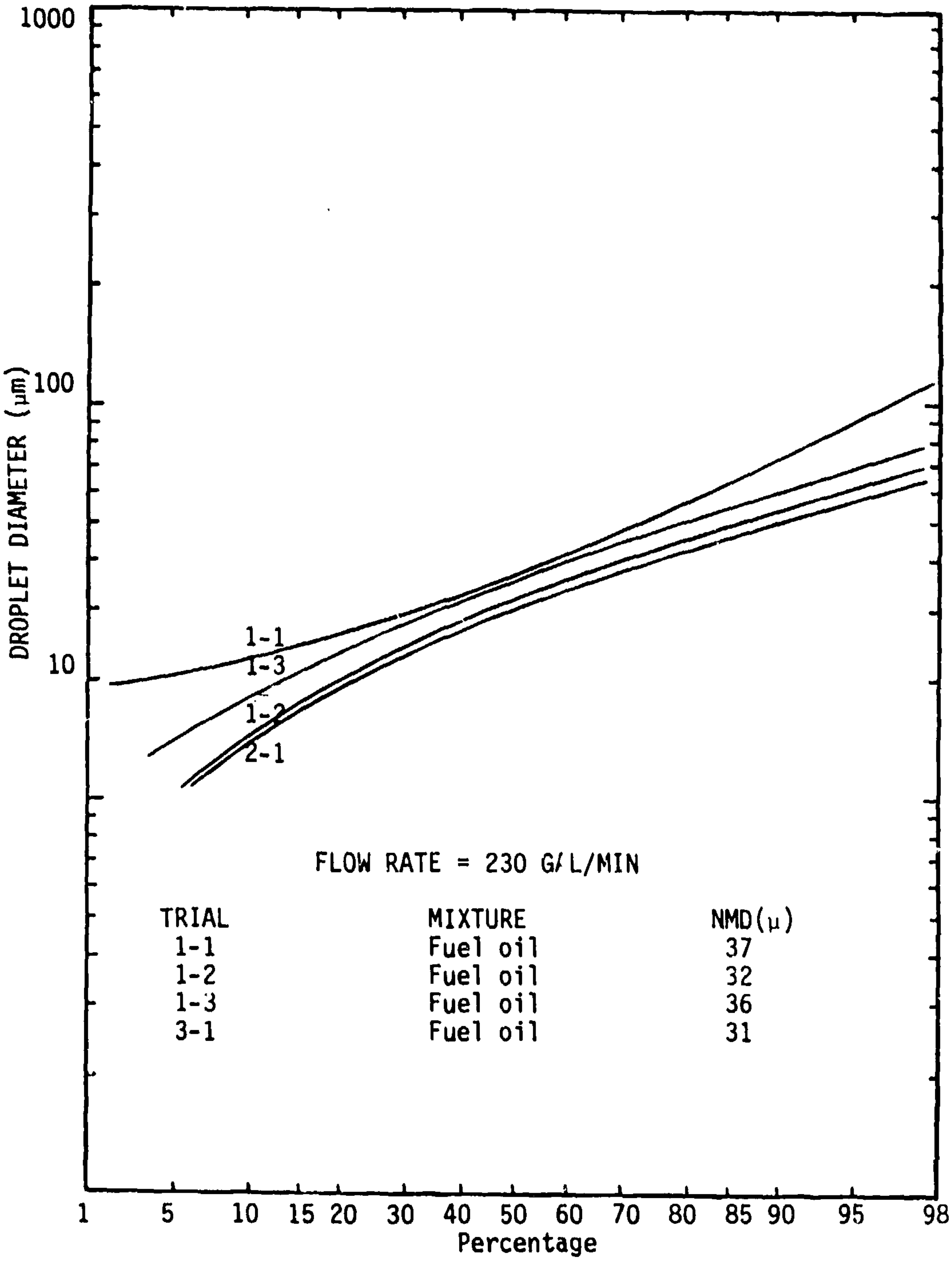

Figure 2-5 Cumulative Numerical Distribution of Droplets as a function of Droplet Diameter.

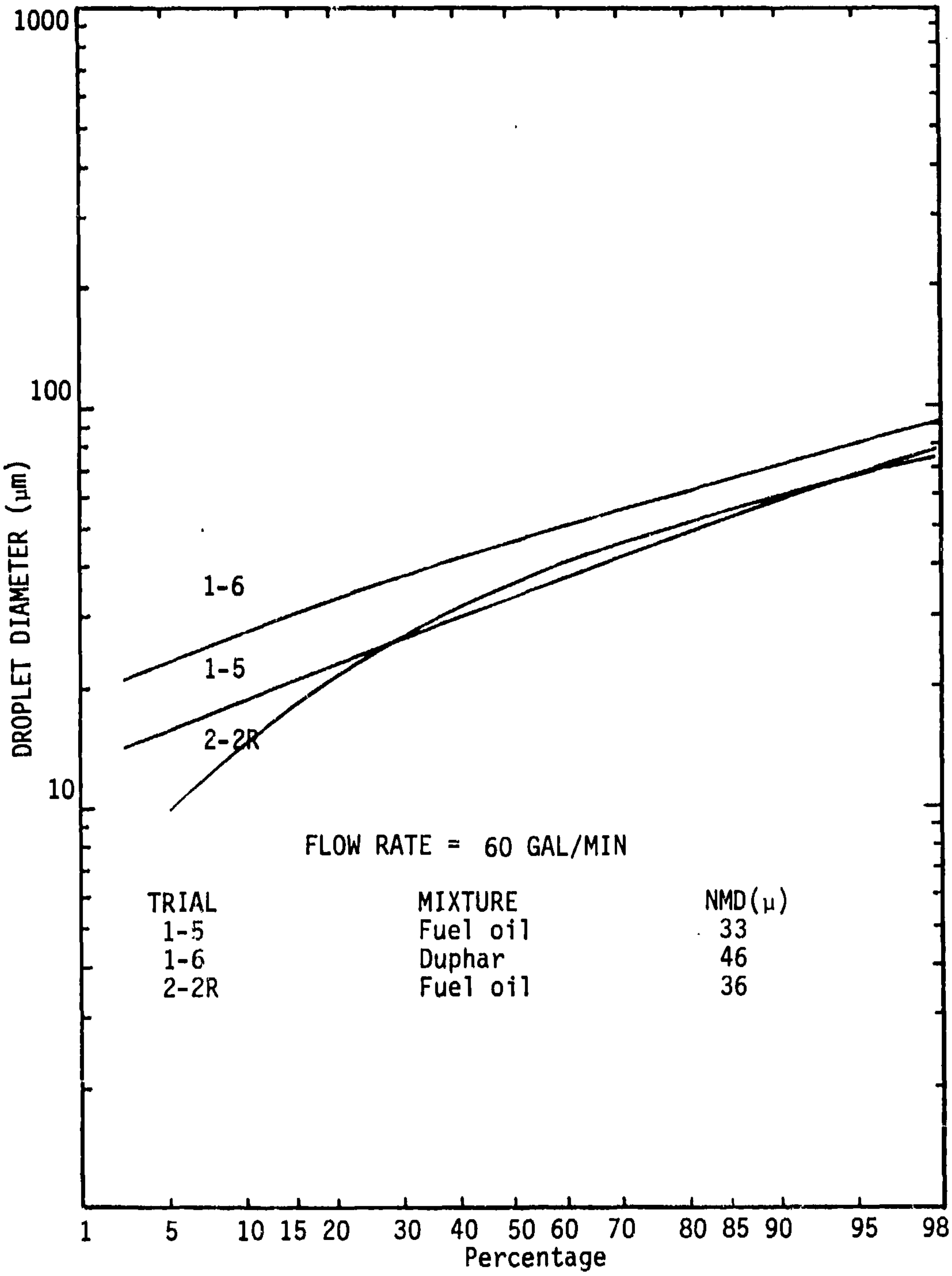

Figure 2-6 Cumulative Numerical Distribution of Droplets as a function of Droplet Diameter.

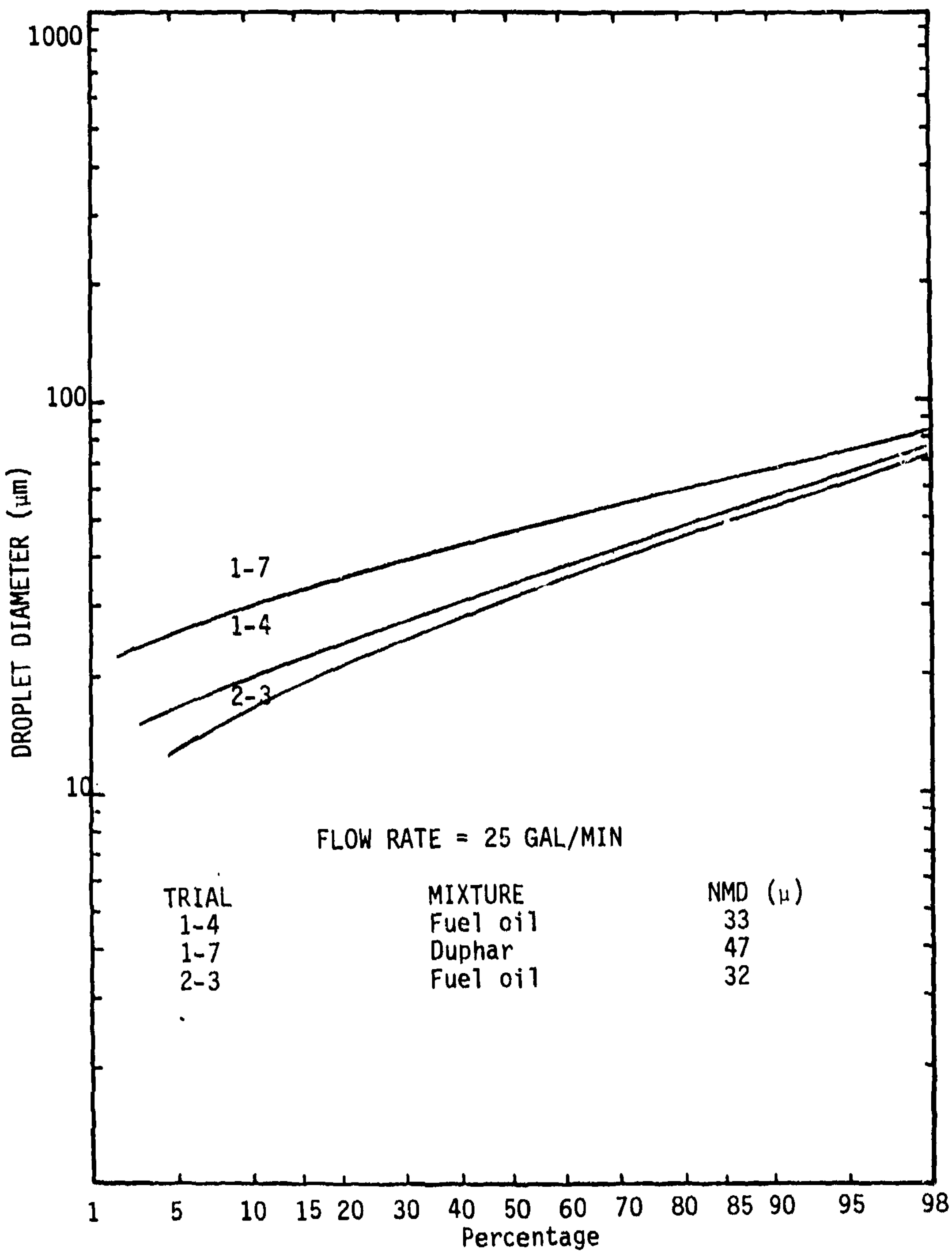

Figure 2-7 Cumulative Numerical Distribution of Droplets as a function of Droplet Diameter.

REFERENCE

1. Dugway Proving Ground, Utah Characterization of DC-7B Aerial Spray System, USATECOM Project No. 5-CO-153-000-029, Test Plan (DPG-TP-C980A) by J.W. Barry, C.O. Eckard, P. Cheeseman and H.E. Cramer, June 1974.

CHAPTER 3. FIELD-TEST METHODS

3.1 TEST CONCEPT

3.1.1 Test Design Factors

a. The test concept, field test and assessment methods used were predicated on the need to acquire empirical data to characterize the performance of a DC-7B aerial spray system. The four critical types of data required to evaluate aerial spray systems are:

(1) The amount (mass) and associated droplet spectra of the spray at ground level.

(2) The droplet-size distribution and application rate achieved by the system for various flow rates and meteorological conditions, release height, flight direction and speed.

(3) The effect of spray operational parameters and meteorological conditions on downwind drift.

(4) The swath width of the spray at selected deposition levels over a range of operational spray parameters.

b. Printflex-card samplers (Figure 3-1) were used to collect the droplets deposited at ground level. These samplers were assessed using two automatic droplet-sizing and counting systems supplemented by manual counting and sizing. Droplet data were evaluated to estimate the mass, number median diameter (nmd) and volume median diameter (vmd) collected with these data to estimate the mass and number of droplets within each selected droplet size increment for each sampling site in the deposition pattern.

c. The vertical mass distribution of the dissemination line was evaluated to define the shape of the released cloud near the dissemination line, the dissemination efficiency of the system and the effect of aircraft turbulence on the cloud.

A 300-foot sampling tower equipped with wind speed and direction instruments and cylindrical impact samplers was used to estimate the mass distribution of the spray as well as vertical expansion of the cloud during initial downwind travel. Qualitative estimates of system efficiency were also obtained. The tower is shown in Figure 3-2.

d. The reduction of mass deposited at ground level from the release line to a downwind distance of 2 to 5 kilometers was estimated. Sampling lines 10 to 15 miles downwind of the release were used to obtain evidence of the downwind drift of small droplets.

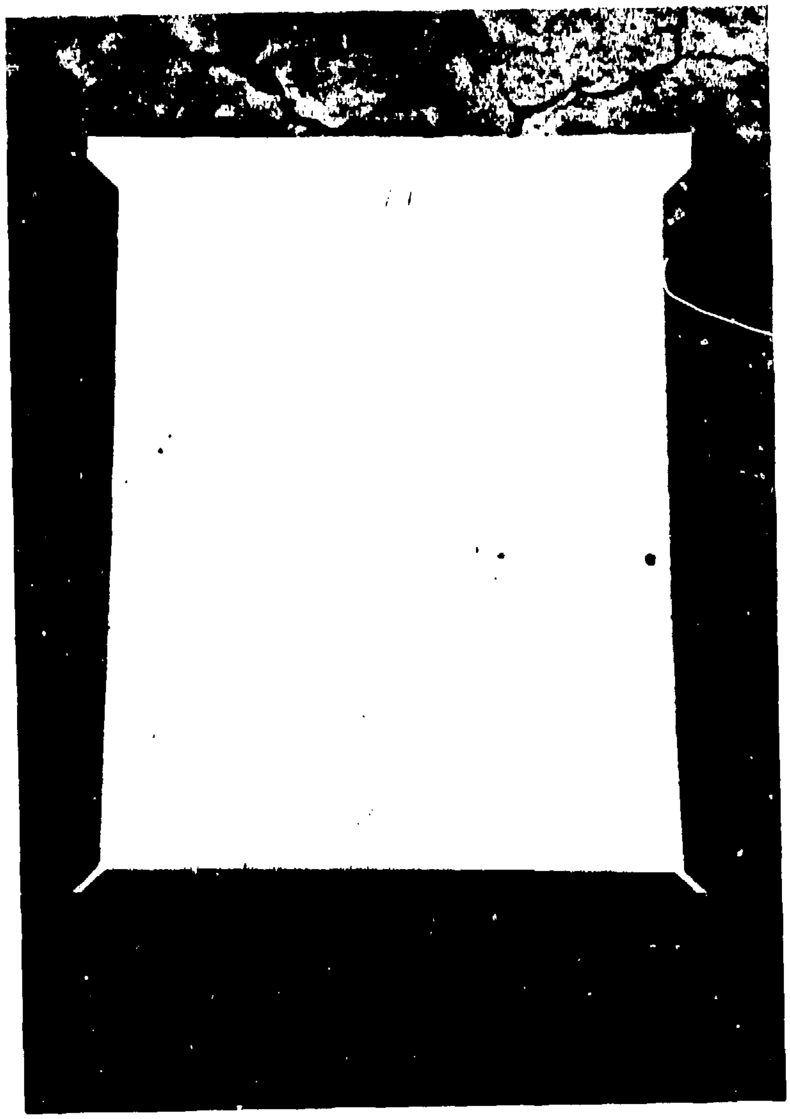

Figure 3-1. Printflex Card, Deposition Sampler

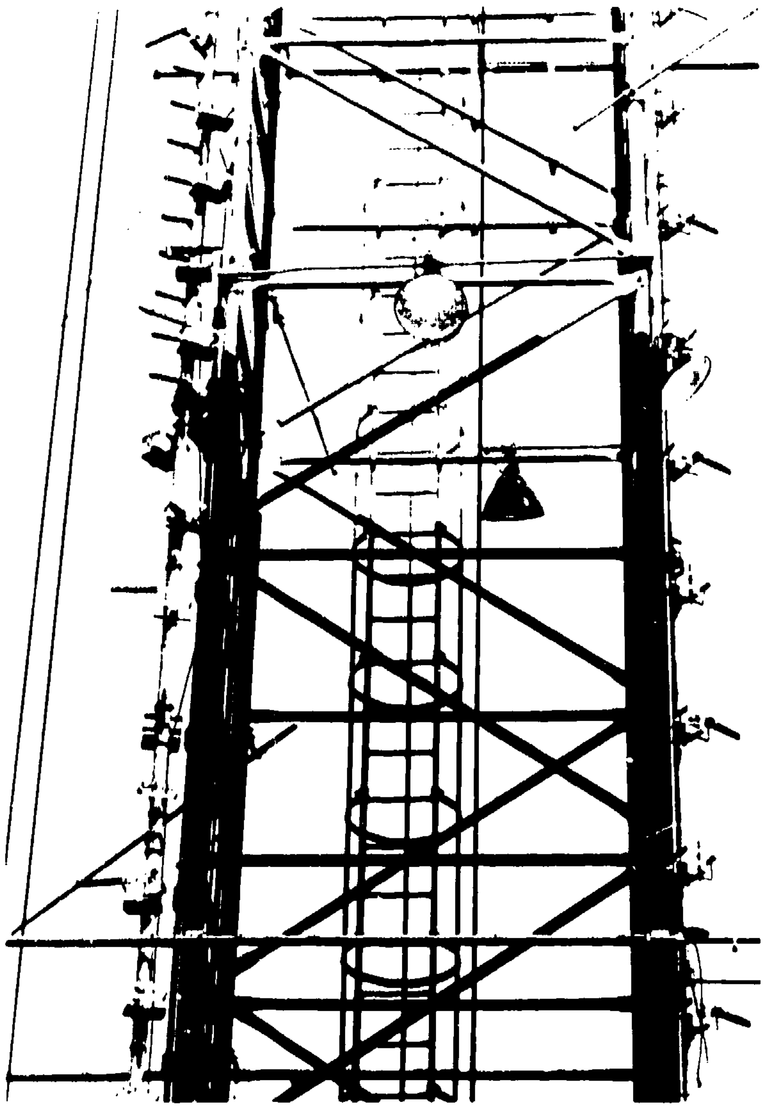

Figure 3-2. Vertical 300' Sampling Tower

A variety of sampling and assessment methods were employed to provide information needed for a preliminary evaluation of the spray system and to isolate shortcomings of the test design. The evaluation of the data will permit improvement of test methods for the collection of quantitative data.

e. Accurate measurements of release height, aircraft speed, and length of the spray line using photometric techniques were required to evaluate the effect of the aircraft operational parameters on the resulting deposition pattern and computation of cloud displacement and cloud configuration immediately after release.

3.1.2 Basis of Sampler Selection (References 1-12)

DPG has routinely conducted investigations to (1) develop efficient sampling methods required to assess vapors, particulates, coarse aerosols, (droplets having diameters $\geq$200 micrometers) and mixed aerosols, (droplets having diameters of 10 to 150 micrometers); (2) determine the collection efficiency of a variety of sampling devices for the assessment of vapor-particulate concentration, deposition density of spray fallout, and fluorescent tracers; (3) develop empirical techniques to define the influence of micrometeorological parameters, mesoscale circulation, atmospheric structure, and diffision phenomena on cloud transport, deposition, and depletion; and (4) develop and design field sampling arrays for various dissemination methods.

a. The collection characteristics of Printflex-card samplers, Kromekote samplers and filter-paper samplers were compared, and significant differences in droplet definition or mass accountancy were isolated (1, 2, 3, 4). Hence, Printflex-card samplers were selected for assessment of deposition at ground level. These samplers have demonstrated a capability to provide satisfactory results in the assessment of spray systems dispersing the same mixture.

b. Results given in References 4 and 5 indicate that the collection efficiency of pipe cleaners for droplets 5 to 150 micrometers in diameter is $\geq$90 percent at wind speeds of 1.0 to 8.0 meters per second. The pipe cleaner is significantly more efficient in the collection of a mixed liquid aerosol than glass rods or rolled filter paper. The expected volume median diameter for this system was below 70 micrometers; therefore pipe cleaners were the samplers of choice for assessment of the vertical cloud profile and for the estimation of decrease in aerosol mass 1.5 meters above terrain during downwind travel.

c. The influence of meteorological parameters on deposition patterns and cloud depletion have been extensively documented (References 8 to 10). The meteorological instruments used in support of this program have provided the data required for parameter estimates.

d. The minimum number of samplers and the grid configuration required to obtain optimum sampling results for a variety of dispersal methods is documented in References 11 and 12. The grids used in this test were designed to obtain the data needed to evaluate the test objectives under the meteorological restrictions and flight patterns imposed.

3.2 METHODS

3.2.1 Spray Formulations

Three spray mixtures were used in this test. The ingredients for each trial are shown in Table 3-1. Specific details of the mixtures and problem areas encountered are given on the following page.

3.2.1.1 Fuel Oil, No. 2/CI 258 Red Dye. Fuel Oil No. 2 was dyed with CI 258 Oil red dye at the rate of 5.0 grams per liter (0.5 percent). Efforts to suspend 6.0 grams (0.6 percent) of dye per liter of fuel oil were unsuccessful. In practice, the spray formulation was mixed in 400-gallon batches using 20 pounds of CI 258 dye per batch. This mixture should have resulted in 0.6 percent dye per liter of fuel oil, but laboratory analysis indicated that only about 0.5 percent of the dye remained suspended in solution. This mixture was used in Trials 1-1, 1-2, 1-3, 1-4, 2-1, 2-2, and 2-3.

The dye content was determined by laboratory analysis of samples taken from the spray tank. Results of these analysis are as follows:

Trial	Dye Content (Grams/Liter)
1-1	5.0
1-1R	No Data
1-2	5.0
1-3	4.8
1-4	4.8
2-1	5.0
2-2	5.0
2-2R	No Data
2-3	5.0

3.2.1.2 Duphar/CI Dye. Duphar, a proprietary solvent furnished by Midair, was dyed with CI 258 dye (5 grams per liter of solvent). Efforts to suspend 10 grams dye in a liter of solution were unsuccessful. This mixture was used in Trials 1-6 and 1-7. The dye content determined by laboratory analysis of the samples for Trials 1-6 and 1-7 was 4.3 and 4.4 grams per liter, respectively. The solubility of CI 258 dye in Duphar was determined to be 5.8×10^{-3} grams per milliliter. The solution

stability of CI 258 dye was monitored for 3 weeks; no loss in color was noted.

TABLE 3-1 SPRAY FORMULATIONS

Date of Trial	Trial Number	Spray Formulation Fuel Oil #2 (gal)	Dupont Oil Red Dye (lb)	Phillips Duphar (1)	Endosulfan (lb)	Zinc Cadmium Sulfide (lb)
4 Oct	1-1	400	20	-	-	-
8 Oct	1-1R	400	20	-	-	-
8 Oct	1-2	400	20	-	-	-
9 Oct	2-1	400	20	-	-	-
9 Oct	2-2	400	20	-	-	-
10 Oct	2-2R	400	20	-	-	-
10 Oct	2-3	400	20	-	-	-
15 Oct	1-4	400	20	-	-	-
15 Oct	1-3	400	20	-	-	-
16 Oct	1-7	-	15	1195	-	-
17 Oct	1-6	-	15	1195	-	-
17 Oct	1-5	270	13.5	-	20	2.4

3.2.1.3 Fuel Oil No. 2/CI 258 Dye/Fluorescent Particles (FP)/ Endosulfan. This formulation used in Trial 1-5 was prepared by mixing 13.5 pounds of CI 258 oil red dye, 2.4 pounds of green zinc cadmium sulfide fluorescent particles (FP), and 20 pounds of Endosulfan (1, 2, 3, 4, 7, 7-hexachloro bicyclo (2.2.1)-2-heptene-5, 6 bisoxymethylene sulfite) into 270 gallons of fuel oil. The dye content of the mixture was determined to be 5.8 g/l. Analysis indicated the mixture contained FP as follows:

Tank No.	Time	Weight FP/ gallon[a]
5	Preflight	0.7 g
5	Postflight	0.95 g
6	Preflight	0.65 g
6	Postflight	1.6 g

[a] The expected weight of FP was 4.03 grams per gallon, based on the weight of FP used to prepare the mixture.

3.2.3 Sampling Grids and Methods

The first nine trials were scheduled to be conducted on the ASG. Downwind sampling out to 15 miles was planned for five trials on the ASG. This extended sampling was used in a single trial (Trial 1-5). Target S was to have consisted of a 3-mile-square dense array containing 821 stations plus three downwind sampling lines containing 30 sampling stations, each extending another 3 miles downwind of the perimeter of the dense array. This design was reduced to three crosswind lines and three downwind lines comprising 606 sampling stations. This reduction in the test matrix and grid design changed the objective of providing a quantitative evaluation of the spray system to one in which a preliminary to semiqualitative assessment would be accomplished.

Three basic grid configurations were used in this test. The grid array for the fly-by trials of Phase 1 (Figures 3-3 and 3-4) consisted of a vertical sampling tower 300 feet (~98 meters) high, with three downwind sampling lines starting approximately 300 meters upwind of the tower and extending 5 miles downwind in all trials except Trial 1-5. The middle line was extended to a downwind distance of 10 miles in Trial 1-5.

The grid design used in Phase 2 (see Figure 3-5) consisted of six sampling lines, each comprising 105 sampling positions spaced 50 meters apart (three acrosswind and three alongwind). All sampling lines were spaced approximately 1,067 meters apart. The specific sampling methods used in each phase follow:

a. In each Phase 1 trial, sampling devices were installed on the 98-meter vertical tower as follows:

(1) A holder containing five cylindrical samplers (pipe cleaners, 2 mm in diameter, 15 cm in length, spaced 2.5 cm apart, and oriented with the long axis of each sampler normal to horizon) were

positioned at 2-meter intervals from 2 through the 92-meter levels. The 46 sampling positions were placed on each of two sides of the tower next to each of the two marked flight lines. Each sampler had a collection area of 4.54 cm^2. The sampling efficiency of the pipe cleaner is estimated to be 90 percent for droplets 20 to 100 microns in diameter when collected in winds of 2 to 12 mph (1 to 6 m/sec).

(2) One inert aerosol sampler (can wrapped with Printflex-card stock) was positioned 20, 40, 60, and 80 meters above terrain on both sampling sides of the tower.

(3) One horizontal Printflex-card (22 x 17 cm) was placed at each of the sampling stations shown in Figure 3.3.

(4) In Trial 1-5, the above Printflex-card sampling array was augumented with a pipe-cleaner sampler and rotorod samplers equipped with H and U rods. These samplers were positioned 1.5 meters above terrain at each of 59 sampling positions of the middle downwind row. The middle row was extended to a distance of 10 miles from the release line.

b. In each trial of Phase 2, one horizontal Printflex-card sampler was placed at each of the 630 sampling stations shown in Figure 3-5.

3.2.4 Aircraft Spray Methods

In each trial, nozzles of the DC-7B aerial spray system were configured to produce a flow-rate of 25-, 60-, or 230-gallons per minute by Midair personnel.

a. In each trial of Phase 1, the aircraft flew above one of two marked flight lines 4 miles long and 91.4 meters (300 feet) southeast or northwest of the 98-meter vertical tower, depending upon the prevailing wind direction. The programmed altitude and ground speed were 45.7 meters (150 feet) and 250 mph, respectively. The aircraft was supposed to disseminate for approximately 4 miles, starting approximately 2 miles before the aircraft passed the vertical tower.

b. In each trial of Phase 2, the aircraft flew into the prevailing wind, across three crosswind sampling lines, at an altitude between 30 and 88 meters above terrain, depending upon the programmed flow rate. The aircraft ground speed was estimated to be 250 mph, and the flight path was marked with panels. Signaling smoke marked the point where release was initiated.

c. Samples of the spray solution were taken for laboratory determination of percent dye, insecticide, and weight of fluorescent particles, as applicable.

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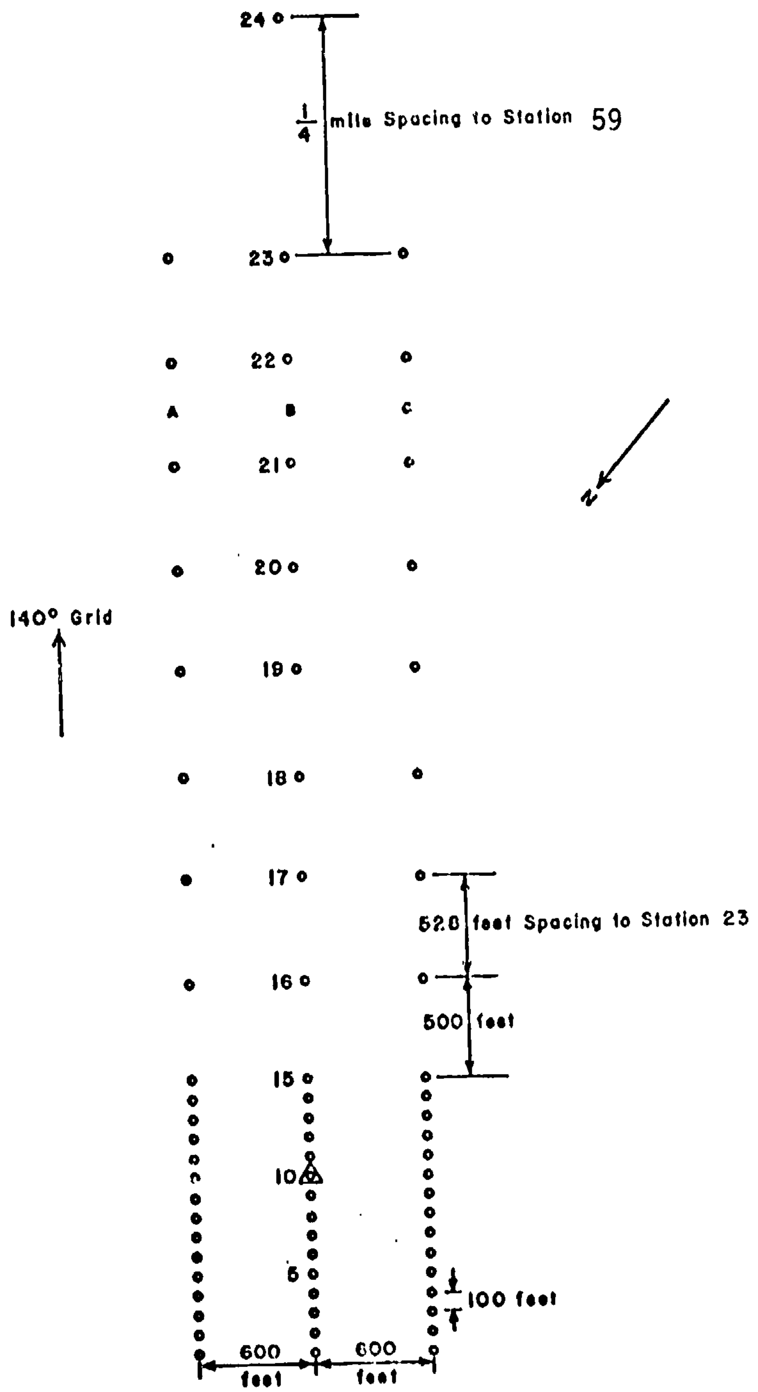

Figure 3-3. Downwind Sampling Grid for Tower Fly-By Trials of Phase 1
Northwest Wind

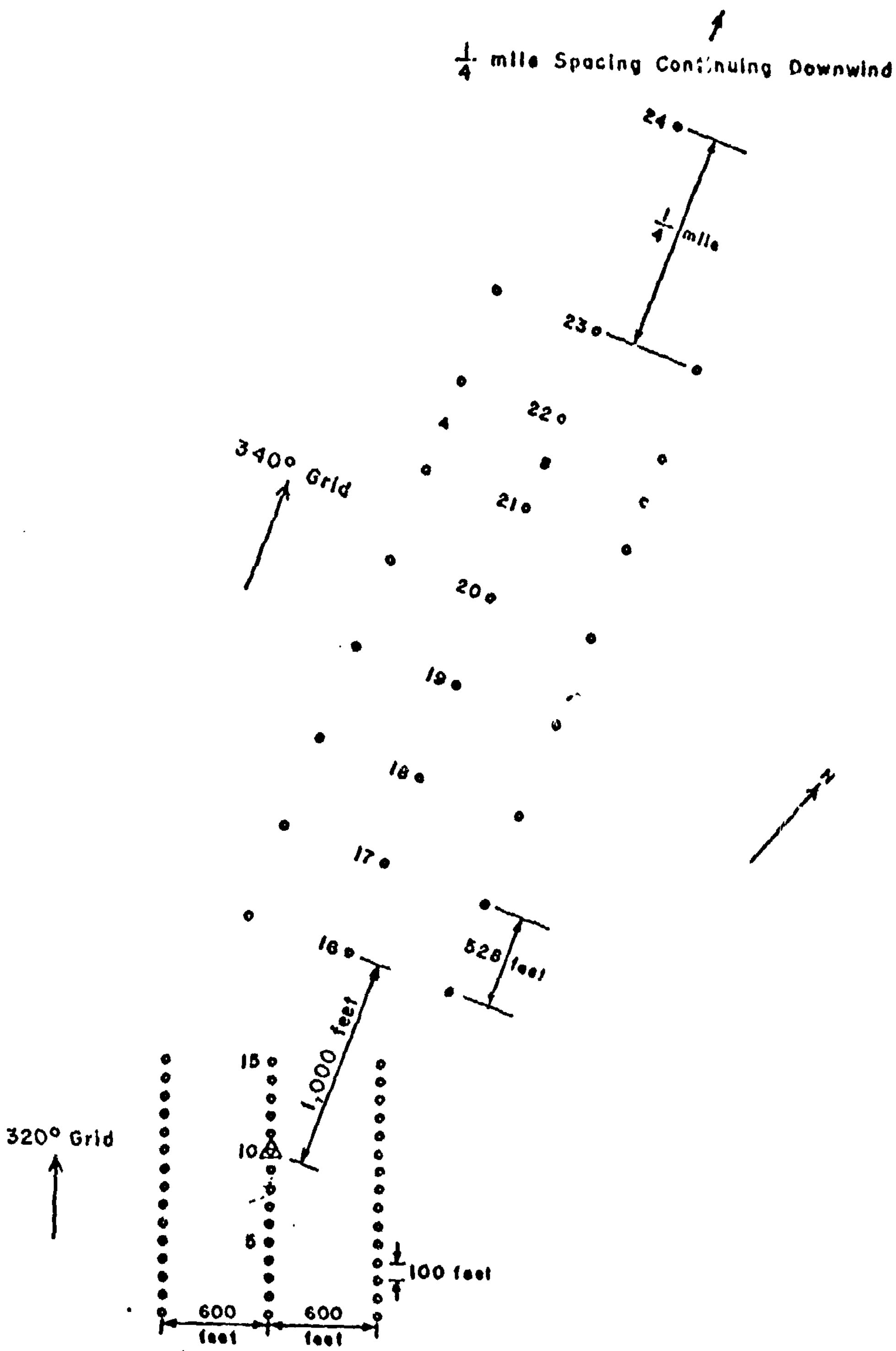

Figure 3-4. Downwind Sampling Grid for Tower Fly-By Trials of Phase 1
Southeast Wind

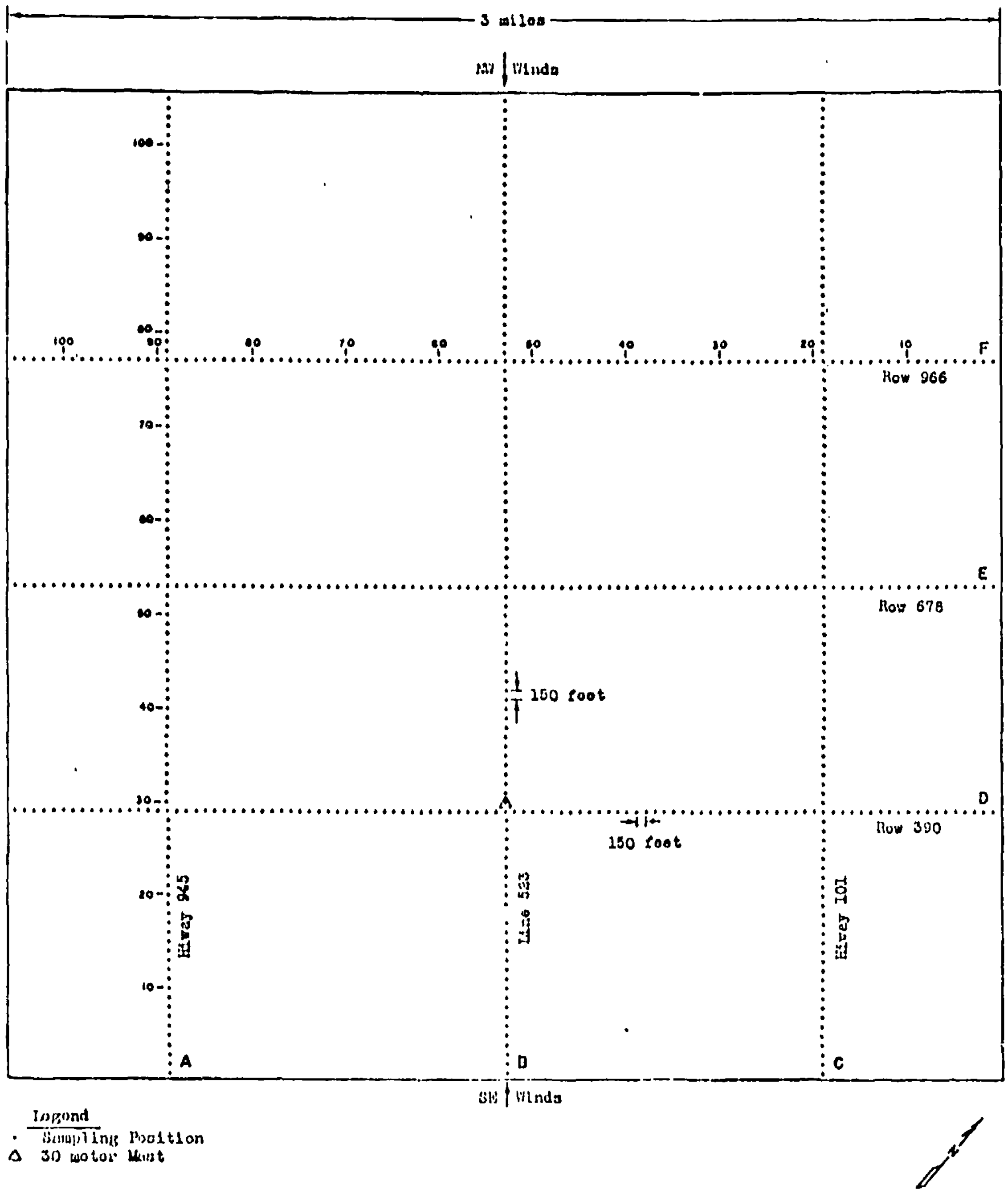

Figure 3-5. Horizontal Grid Array for Phase 2

d. Confirmation of the amount of spray mixture released on each mission could not be determined by the aircraft crew. The system had to be primed by actually disseminating a portion of the load before each trial. The quantity released during the priming operation could not be estimated using the spray-control instruments. Determination of the quantity loaded before and after take off could not be used for estimating the quantity actually released in the trial.

3.2.5 Meteorological Methods

3.2.5.1 Meteorological Restrictions. The meteorological limitations associated with the test design delineated in the test plan were as follows:

a. Phase 1 limitations:

(1)	Wind speed (at release height)	5 to 15 mph
(2)	Wind direction (at release height)	± 15° normal to the release line
(3)	Stability	Very unstable conditions with strong convective activity are not permitted
(4)	Temperature	No restriction
(5)	Relative humidity	No restriction
(6)	Precipitation	None permitted
(7)	Solar radiation	No restriction

b. Phase 2 limitations were identical to those of Phase 1 except:

(1)	Wind speed (at release height)	0 to 15 mph
(2)	Wind direction (at release height)	None

Of the 12 trial attempts, only three trials of Phase 1 (Trials 1-5, 1-6, and 1-7) and two trials of Phase 2 (Trials 2-2R and 2-3) met the meteorological criteria.

3.2.5.2 Meteorolcgical Measurements:

a. Phase 1:

(1) Meteorological measurements were made at the 98-meter tower and at one 100-foot tower ½ mile downwind of the 98-meter tower.

Standard surface observations were taken in the vicinity of the 98-meter tower.

(2) Pilot-Balloon (PIBAL) Measurement. Standard PIBAL measurements were made in the vicinity of the 98-meter tower at release time and as required by the meteorologist in charge.

(3) The rawinsonde observations were made at release time to determine the vertical profiles of wind, temperature and humidity and the depth of the mixing layer.

(4) Tower measurements are shown in Table 3-2.

Table 3-2. Meteorological Measurements at Tower Positions for Phase 1.

Level	Tower 100'	Tower 300'	Wind Speed	Wind Direction	Turbulence	Temp
2 m	X	X	X	X		X
16 m	X	X	X	X	X	
32 m	X	X	X	X	X	X
64 m		X	X	X	X	X
80 m		X	X	X		
96 m		X	X	X	X	X

b. Phase 2:

Standard surface observations were taken near the test area. Measurements of wind speed, wind direction and temperature were taken at standard heights on one 32-meter mast.

3.2.5.3 Photograph Measurements

a. In Phase 1, six Mitchell cinetheodolites and three Multidata 35 mm fixed cameras were positioned to cover both flight lines.

b. In Phase 2, three Multidata 35 mm fixed cameras were positioned at three of the 10 surveyed camera sites in the test area to cover the intended line of flight for each trial. Data acquisition of aircraft speed and altitude during the total dissemination time using this system was not adequate to obtain all of the desired data with precision.

CHAPTER 3. REFERENCES

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CHAPTER 4. DATA ANALYSIS

4.1 SWATH WIDTH

Swath width is the width of a strip of ground receiving a deposition density of a specified level in weight per area (mass) or number of particles per area. Using this definition, two types of deposition densities were considered, one of mass and one of number. Of the 12 trials conducted, 10 were considered either acceptable or partially acceptable for data analysis. Trials 1-1R and 2-2 had system malfunctions and were not used.

The original test plan called for 18 to 20 field trials under restrictive meteorological criteria. Had these trials been conducted as scheduled,they would have produced a statistically sound data base to provide definitive swath-width estimates. The variability of meteorological conditions during the available test period and the lack of accurate flow-rate information created a variability within the trial data that cannot be resolved through normal averaging techniques, hence no attempt has been made to do so for either the mass or size-density analysis.

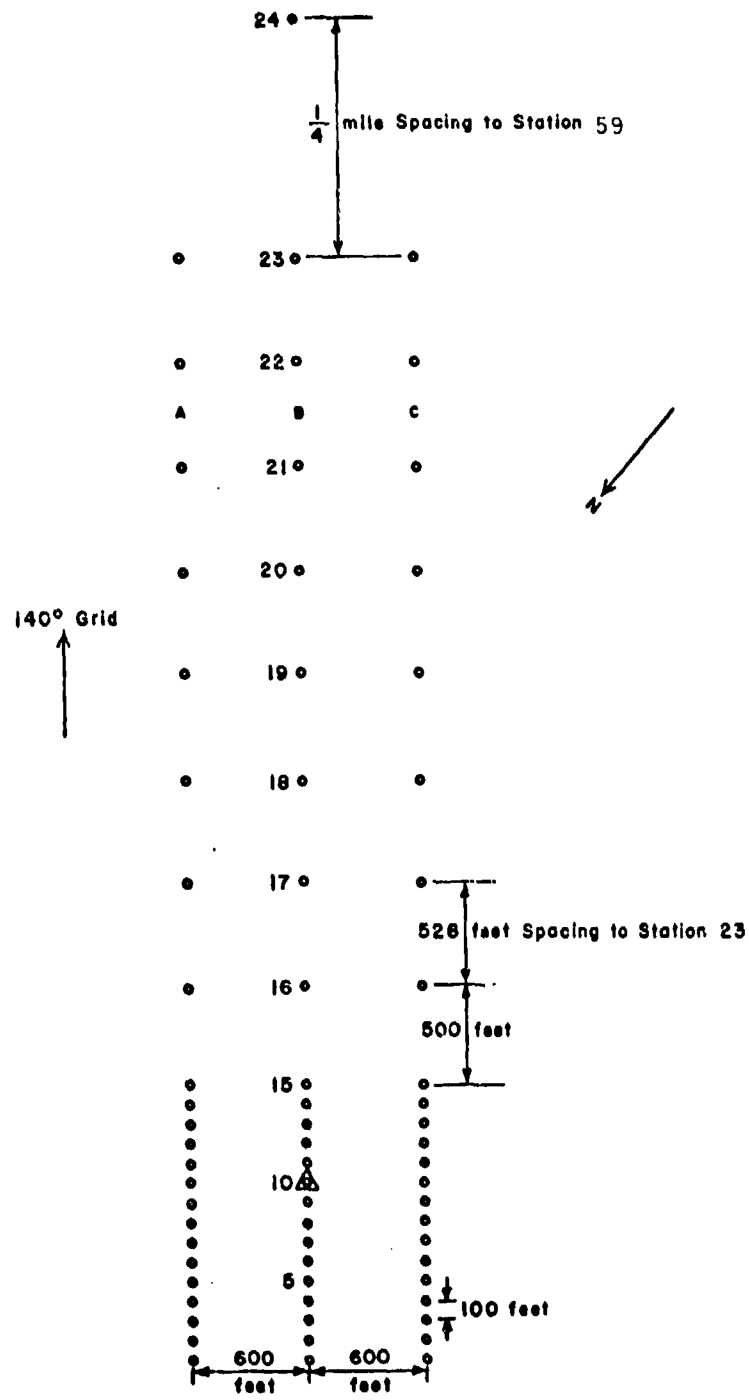
Ground deposition was sampled with Printflex cards at known coordinates on the grid. Printflex-card positions for the grids used are shown in Figures 4-1, 4-2 and 4-3.

The spray formulation in all trials contained a tracer (Dupont oil red dye) to produce drop stains on the Printflex cards. These stains were measured and converted to an assumed spherical particle using the spread factor equation previously discussed. The deposition was calculated from the spherical particles in terms of mass and number at each Printflex-card location.

Two types of trials were conducted based upon wind direction relative to the release line. Trials 1-5, 1-6 and 1-7 are considered crosswind trials. These trials had angular deviations of wind direction from normal to flight line of 15^{o}, 15^{o} and 10^{o}, respectively. Trials 1-1, 1-2, 1-3, 1-4, 2-1, 2-2R and 2-3 were inwind trials and had angular deviations from the dissemination flight line heading of 175^{o}, 48^{o}, and 35^{o}, undetermined, 30^{o}, 10^{o} and 25^{o}, respectively.

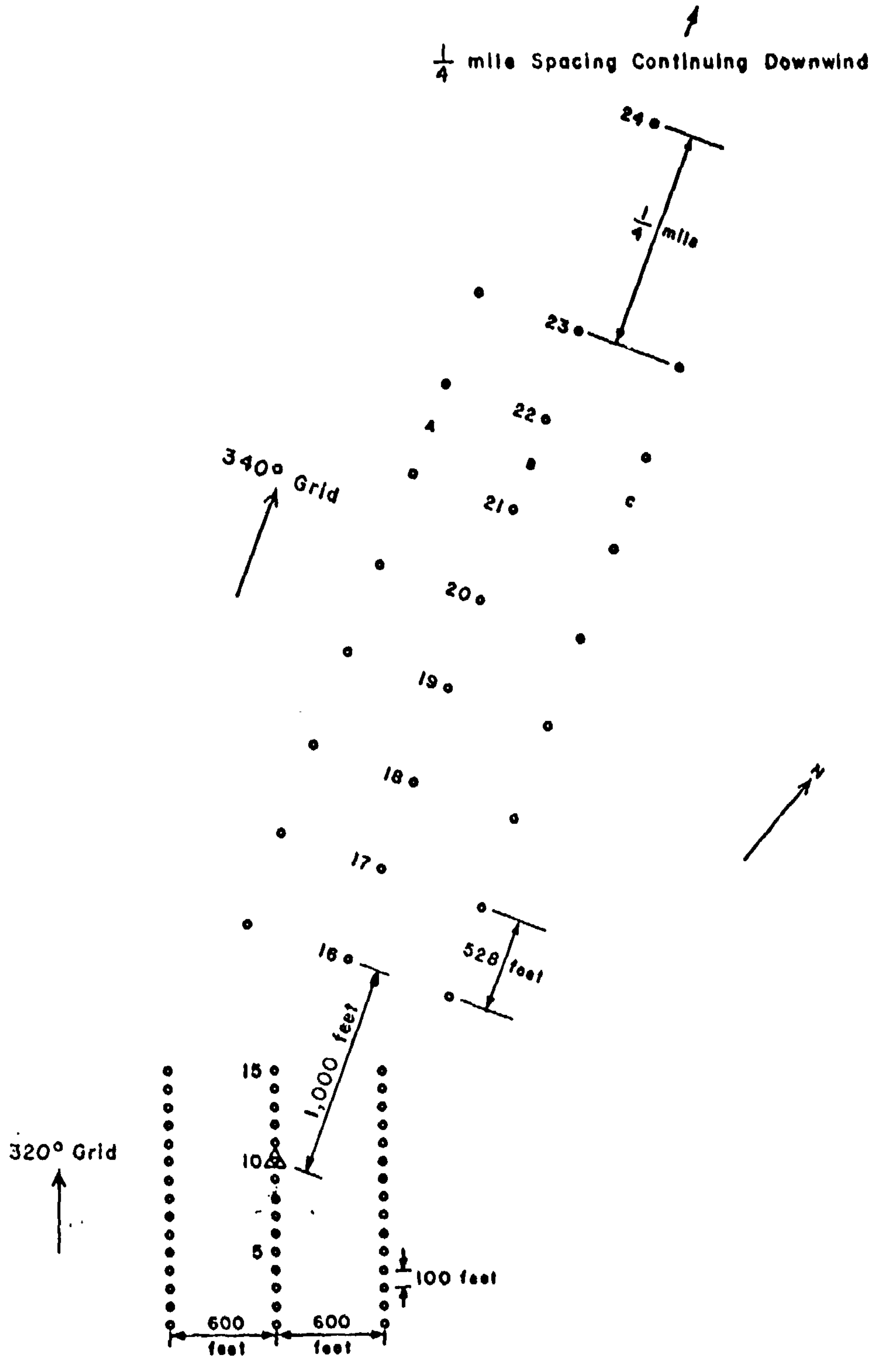
4.1.1 Swath Width from Mass Analysis

The ground deposition density in milligrams per square meter (mass) versus distance was plotted for each trial and each sampling line. The sampling lines were approximately perpendicular to the release line in all trials. Swath widths for deposition densities of 4, 12, 36 and 108 milligrams per square meter were read from these graphs. Mean widths for mass deposition densities were calculated



△ 98m Tower

Figure 4-1. Grid used for NW winds, Trials 1-1, 1-3, 1-5, 1-6, 1-7



△ 98m Tower

Figure 4-2. Grid used for SE winds, Trials 1-2, 1-4

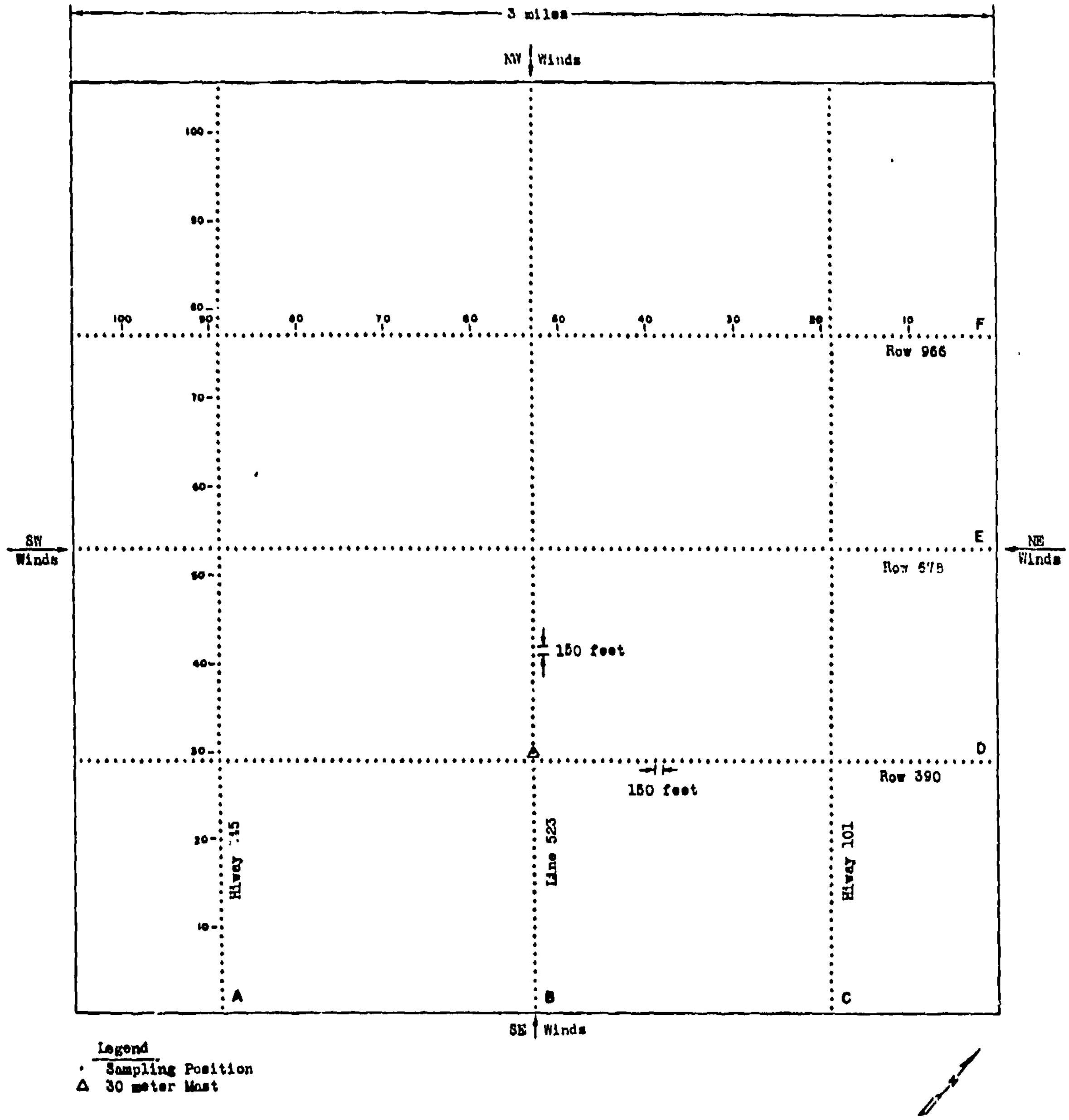


Figure 4-3. Grid used for Trials 2-1, 2-2R, 2-3

from the three sampling lines. In Trial 1-6, only two sampling lines were available for averaging because of problems in sampling. Table 4-1 gives swath widths based on mass.

4.1.2 Swath Width from Particle Size/Density Analysis

The ground deposition densities in droplets per square meter for particle sizes of <21μm, <38μm, <55μm, and <73μm versus downwind distance were plotted for each trial. An average swath width of each trial for particle sizes less than 73μm and for densities of 10,000, 30,000, 90,000 and 270,000 drops per square meter are given in Table 4-2.

Table 4-1. Swath Width Based on Mass

Trial	Programmed Application Rate (gal/min-ℓ/min)	Swath Width (feet-meter)			
		4 mg/m^2	12 mg/m^2	36 mg/m^2	108 mg/m^2
1-1	230-871	897- 273	607-185	298- 89	77-23
1-2	230-871	577- 176	77- 23	--a--	--a--
2-1	230-871	--a--	--a--	--a--	--a--
1-3	230-871	973- 297	627-191	373-114	--a--
2-2R	60-227	692- 211	133- 41	--a--	--a--
1-6	60-227	4325-1318	950-290	395-120	45-14
1-5	60-227	587- 179	170- 52	--a--	--a--
2-3	25- 95	292- 89	--a--	--a--	--a--
1-7	25- 95	593- 181	203- 62	--a--	--a--
1-4	25- 95	363- 111	193- 59	--a--	--a--

[a]deposition density (mass) in column heading not achieved.

Table 4.2 Swath Width Based on Droplet Deposition Density of Particles Less than 73μm

Trial	Programmed Application Rate (gal/min)	Swath Width (feet-meters)			
		10,000 droplets[b]	30,000 droplets	90,000 droplets	270,000 droplets
1-1	230	1525- 465	1047- 319	673- 205	476-145
1-2	230	1709- 521	1293- 394	666- 203	148- 45
2-1	230	2415- 736	1148- 350	62- 19	--a--
1-3	230	>3310->1009	>2382-> 726	>1079->329	614-187
2-2R	60	4383- 1336	2313- 705	535- 163	66- 20
1-6	60	>5144->1568	>5144->1568	1568- 478	453-138
1-5	60	2165- 660	1385- 422	574- 175	276- 84
2-3	25	1434- 437	879- 268	466- 142	161- 49
1-7	25	1539- 469	682- 208	282- 86	105- 32
1-4	25	3934- 1199	1444- 440	384- 177	95- 29

[a] Droplet deposition density in column heading not achieved.

[b] per square meter

4.2 HORIZONTAL RECOVERIES

4.2.1 Horizontal Recoveries by Mass

Horizontal recoveries in terms of mass density in milligrams per square meter over the sampled portion of the grid are presented as contour diagrams in Figures 4-4 through 4-13.

4.2.2 Horizontal Recoveries by Density

The ground deposition densities in droplets per square meter for particle sizes of <21μm, <38μm, <55μm, and <73μm versus downwind distance are presented in Figures 4-14 through 4-20. Isopleths of droplet densities for all droplets less than 73μm are shown in Figures 4-21 through 4-30.

4.2.3 Total Grid Recovery

Table 4-3 presents estimates of the spray material recovered on the horizontal grid. Estimates are given for nine trials. The data from Trial 1-3 were invalidated by the wind direction. A continuation or completion of the test as originally detailed in the plan of test would have provided sufficient data for more definitive estimates of horizontal grid recovery.

Table 4-3. Estimated Percent of Material Recovered on the Horizontal Sampling Grid

Trial	1-1	1-2	2-1	2-2R	2-3	1-3	1-4	1-7	1-6	1-5
Horizontal Recovery (%)	11	2	1	11	11	(a)	21	47	76	11

(a) Wind direction invalidated horizontal recovery.

4.2.4 Horizontal Efficiency

Horizontal efficiency is the percentage of material released from the disseminator and recovered as deposition on the ground.

The technique used in computing horizontal efficiency is very similar to that used in computing vertical efficiency. However, with a significant mass consisting of small drops (<70μm), there is a very large downwind distance associated with deposition. Consequently a very large sampling grid is required, and meteorological conditions should be uniform over an extended period. Since very small particles

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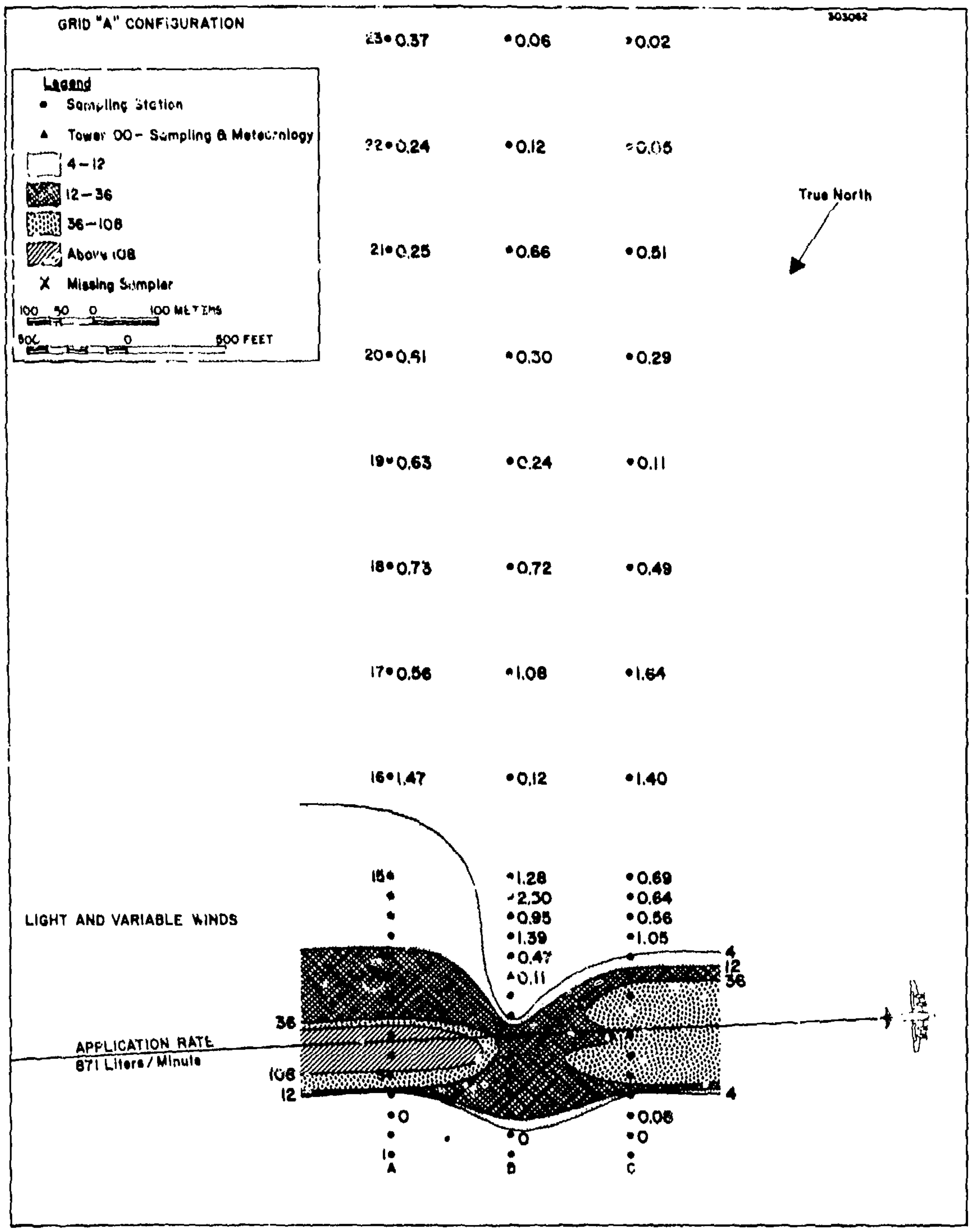


Figure 4.4 Trial 1-1 Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage for the ranges shown.

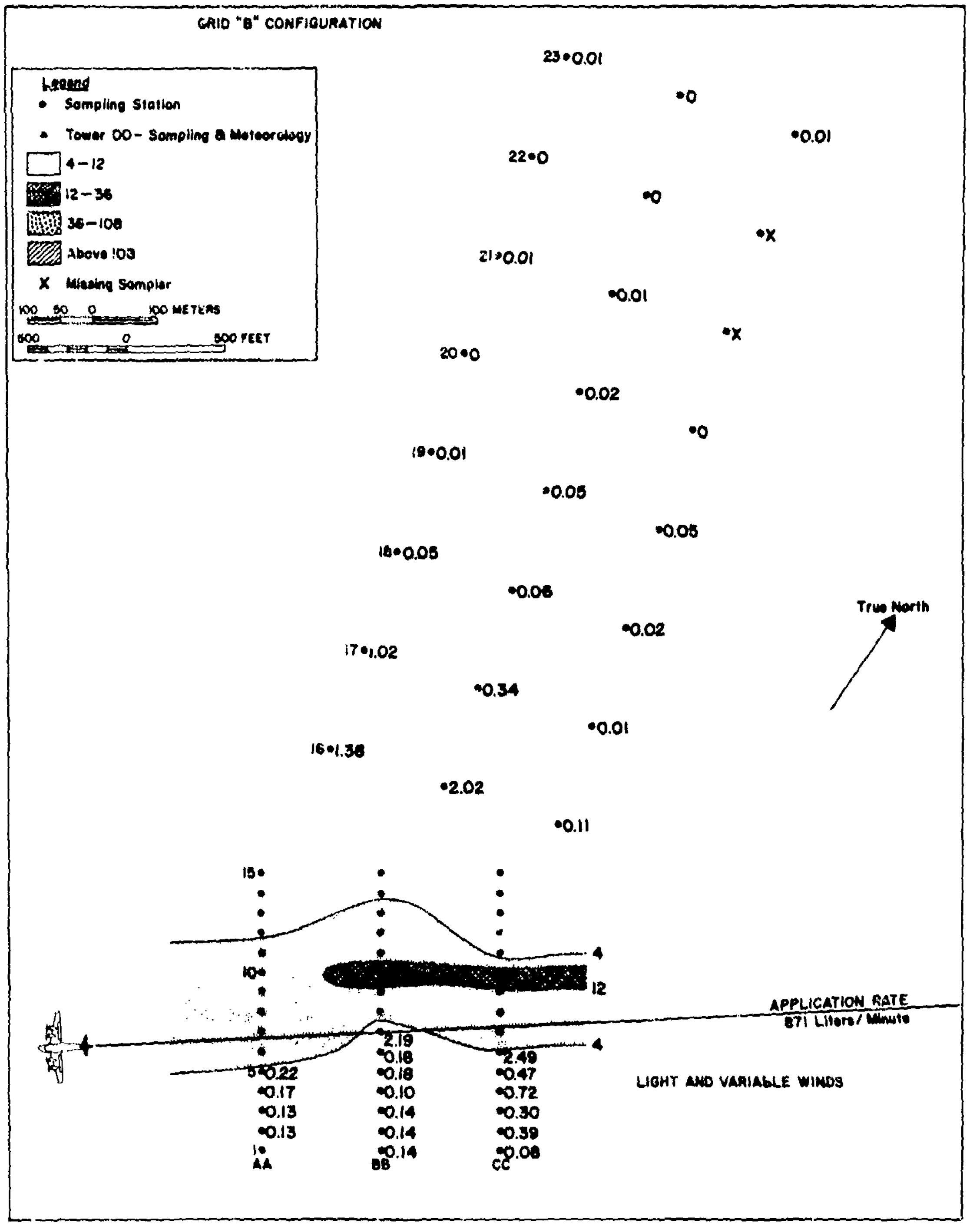


Figure 4.5 Trial 1-2 Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage for the ranges shown.

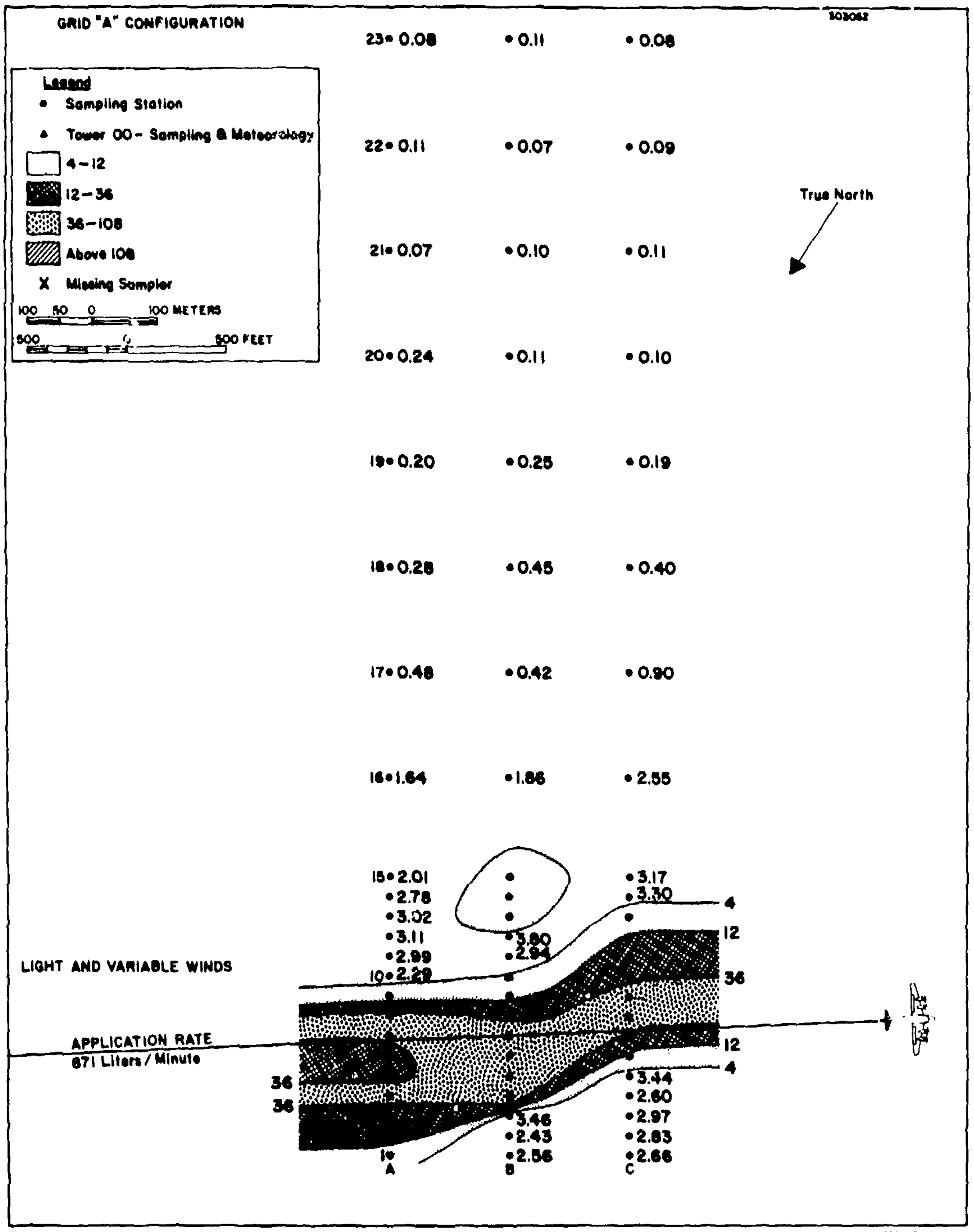


Figure 4.6 Trial 1-3 Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage for the ranges shown.

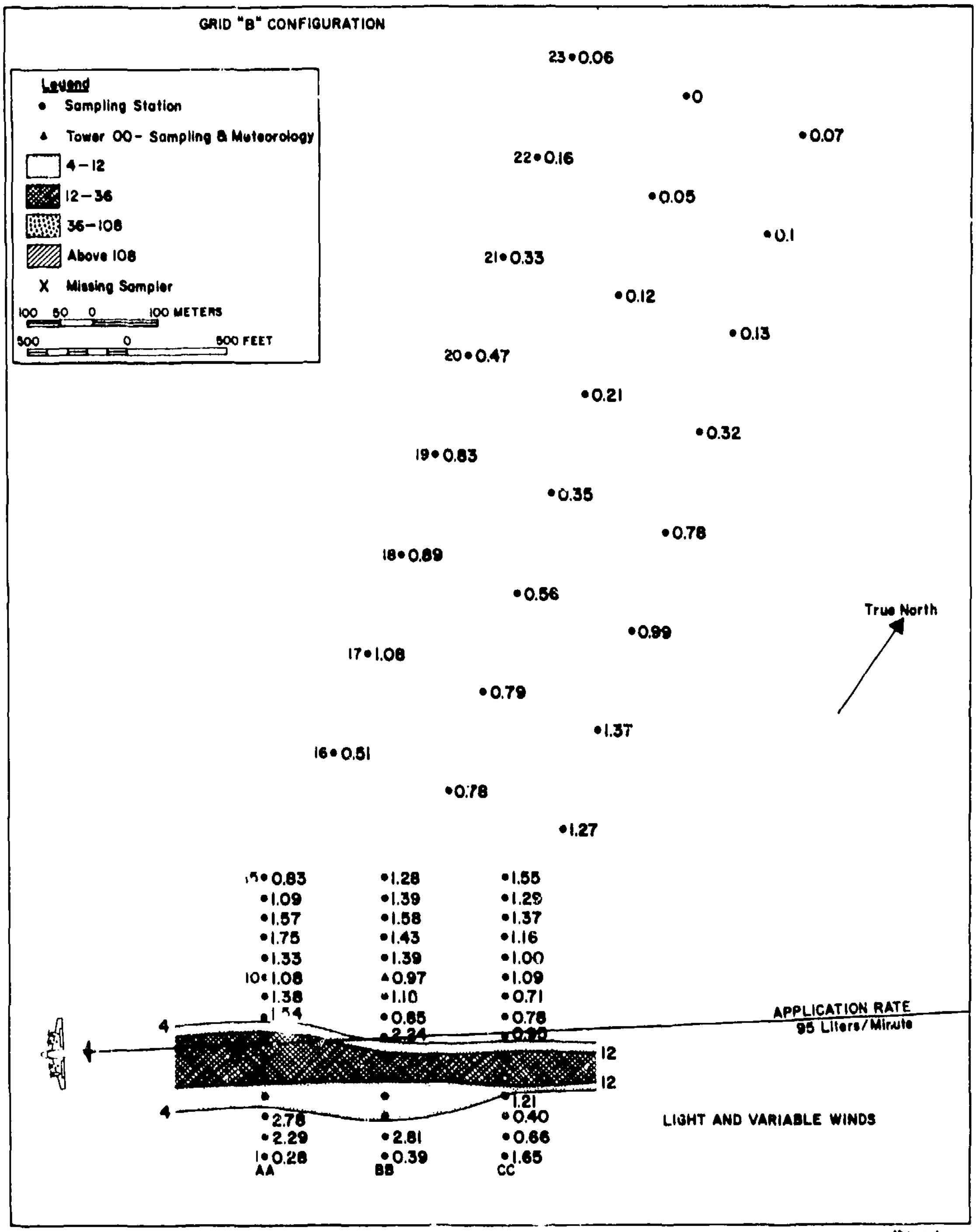


Figure 4.7 Trial 1-4 Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage of the ranges shown.

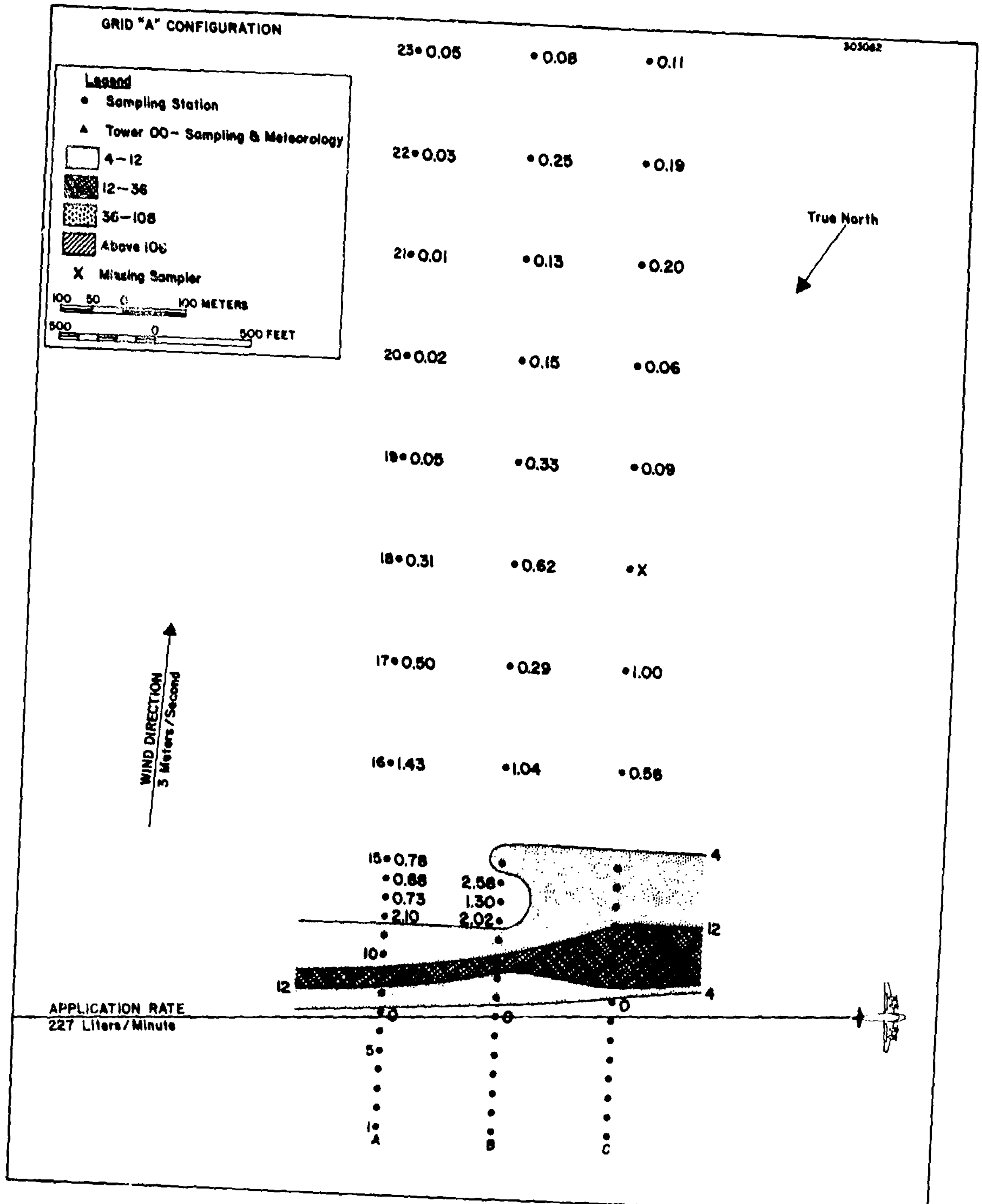


Figure 4.8 Trial 1-5 Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage of the ranges shown.

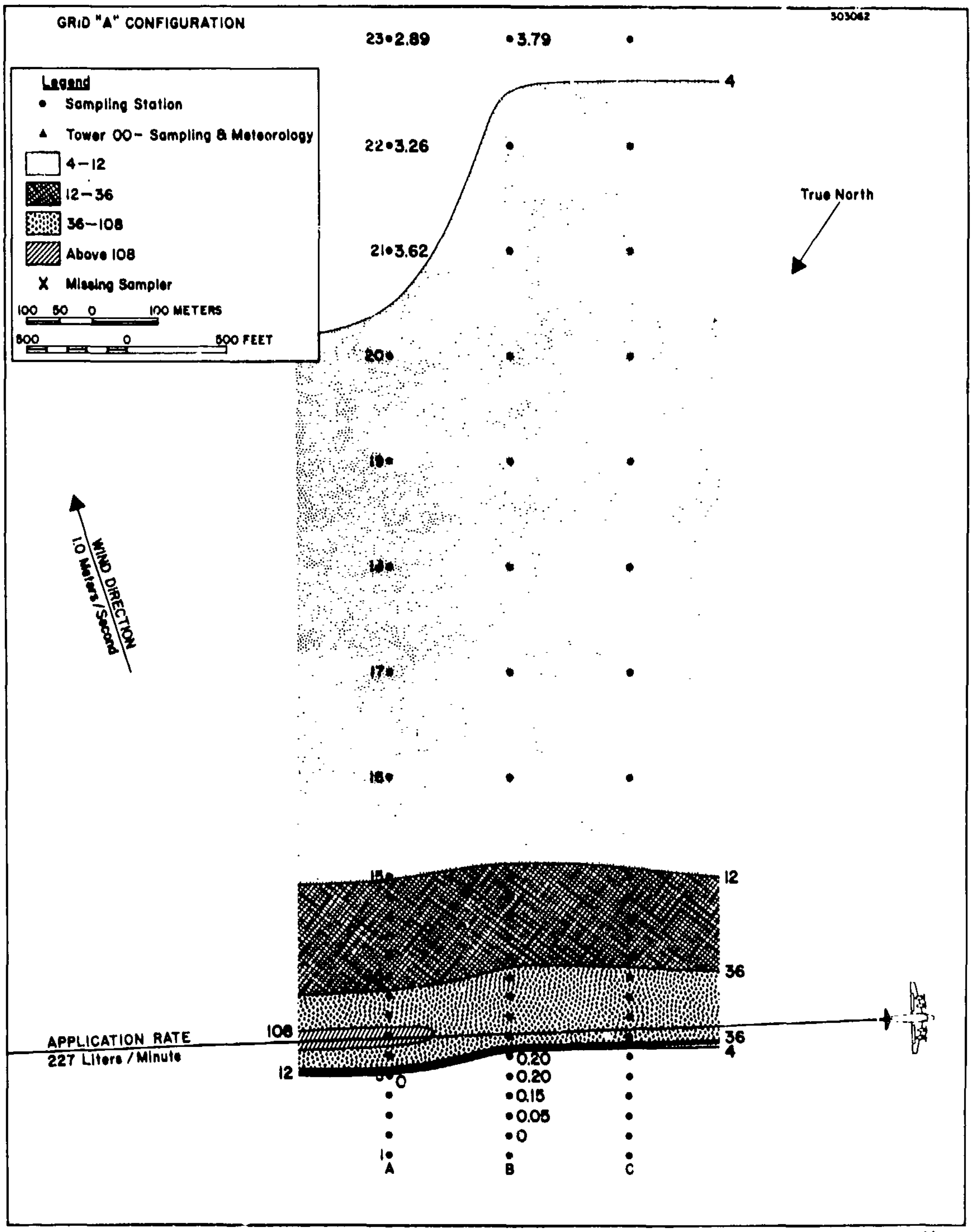


Figure 4.9 Trial 1-6 Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage for the ranges shown.

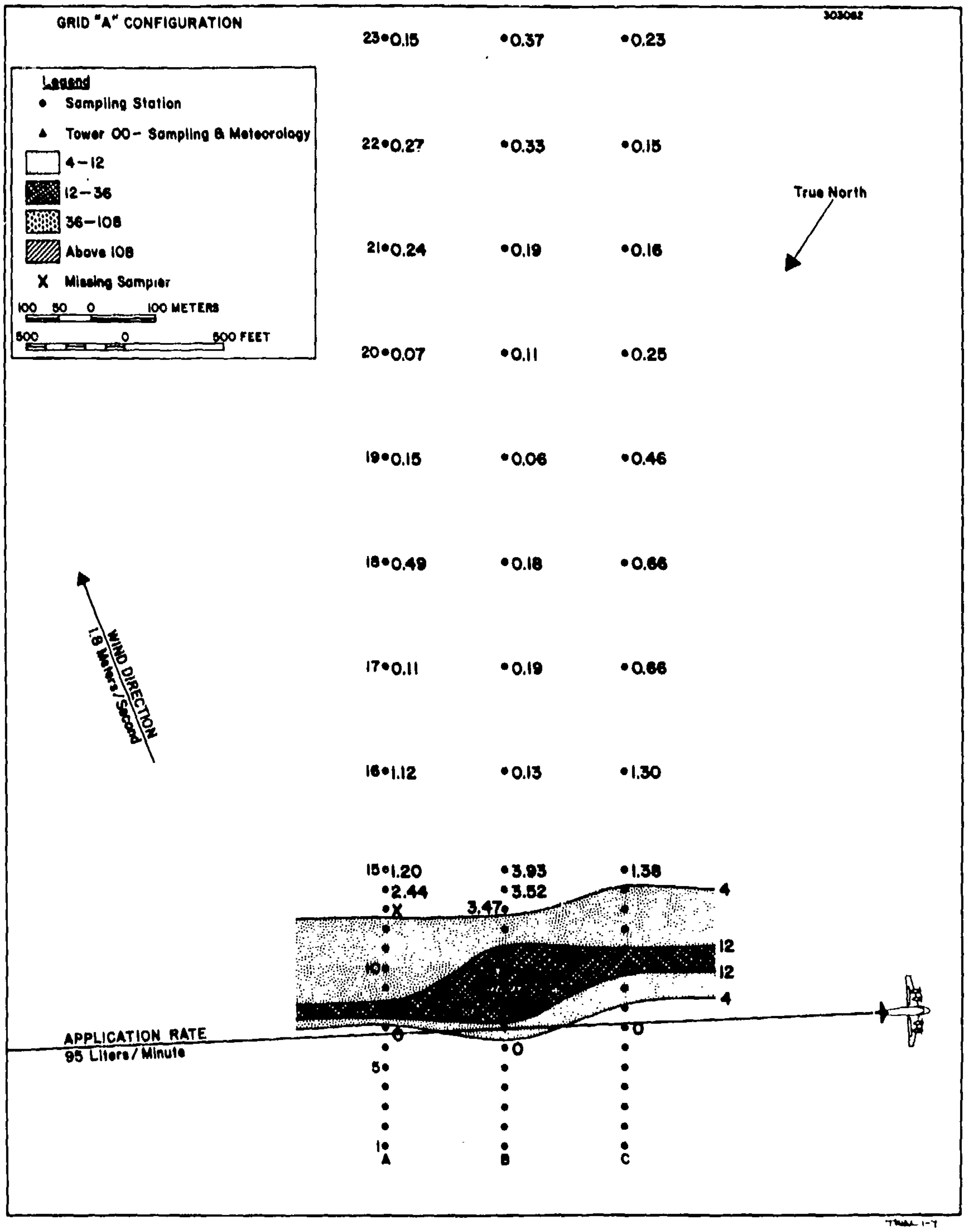


Figure 4.10 Trial 1-7 Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage for the ranges shown.

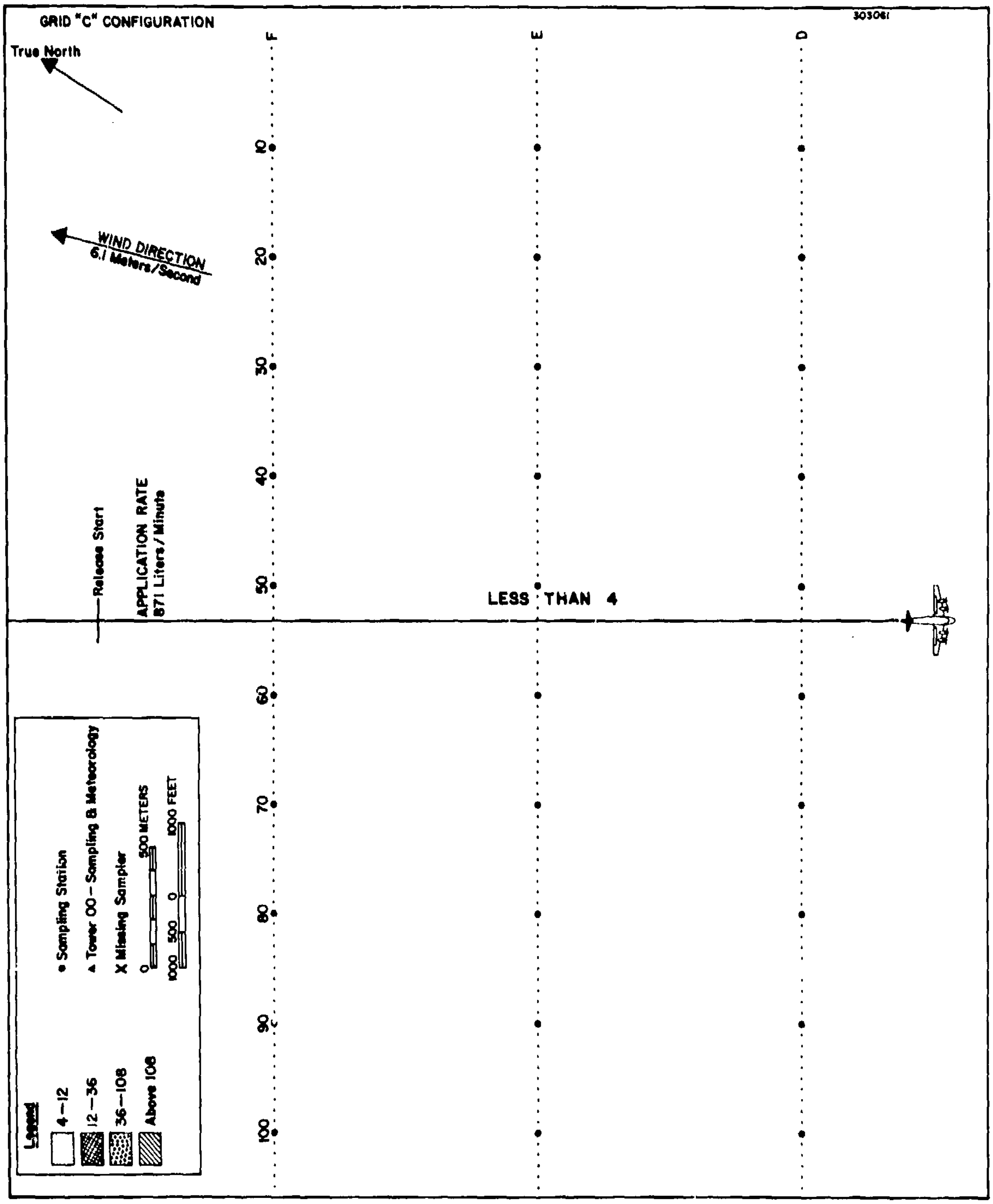


Figure 4-11 Trial 2-1 Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage for the range shown.

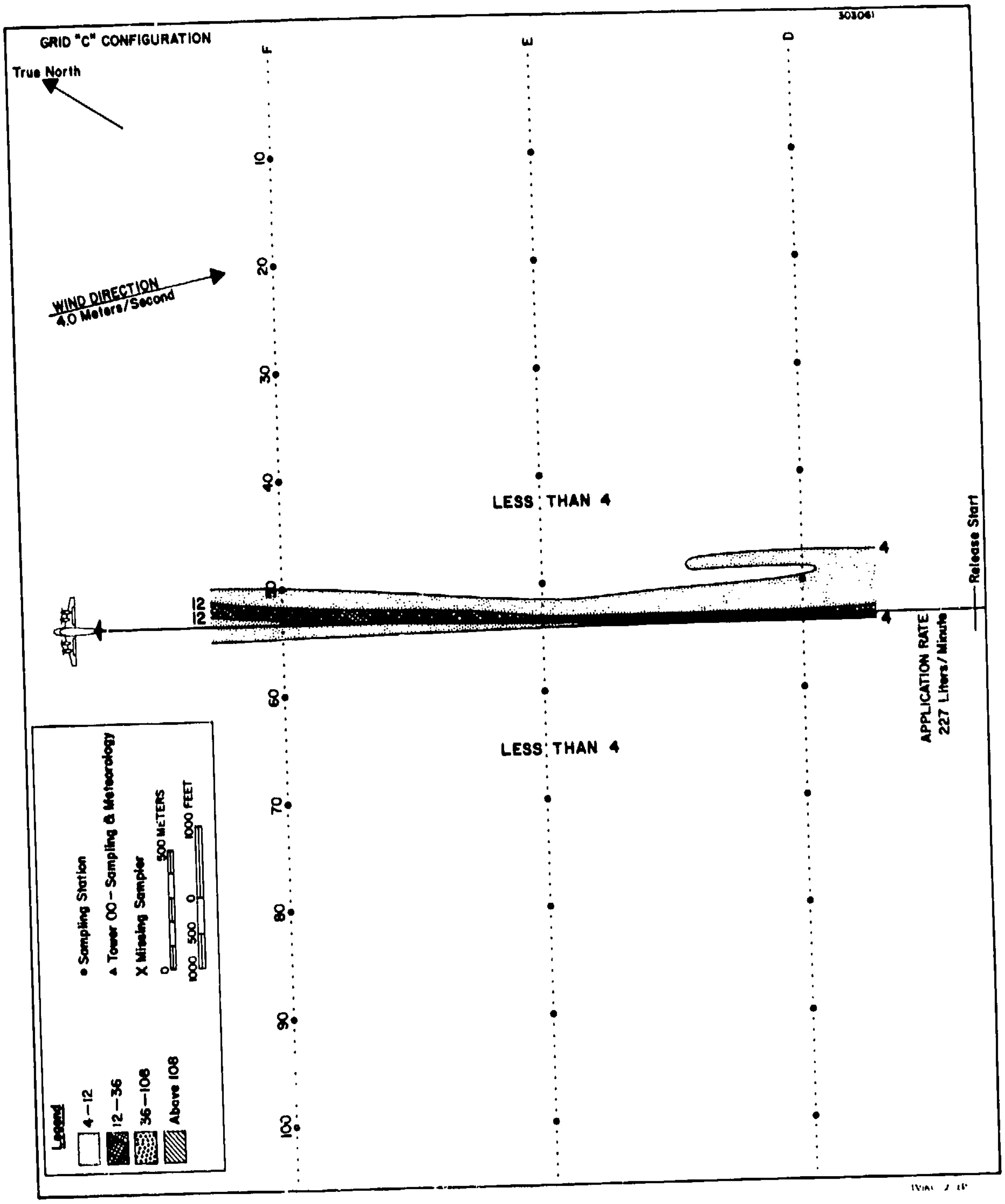


Figure 4-12 Trial 2-2R Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage for the range shown.

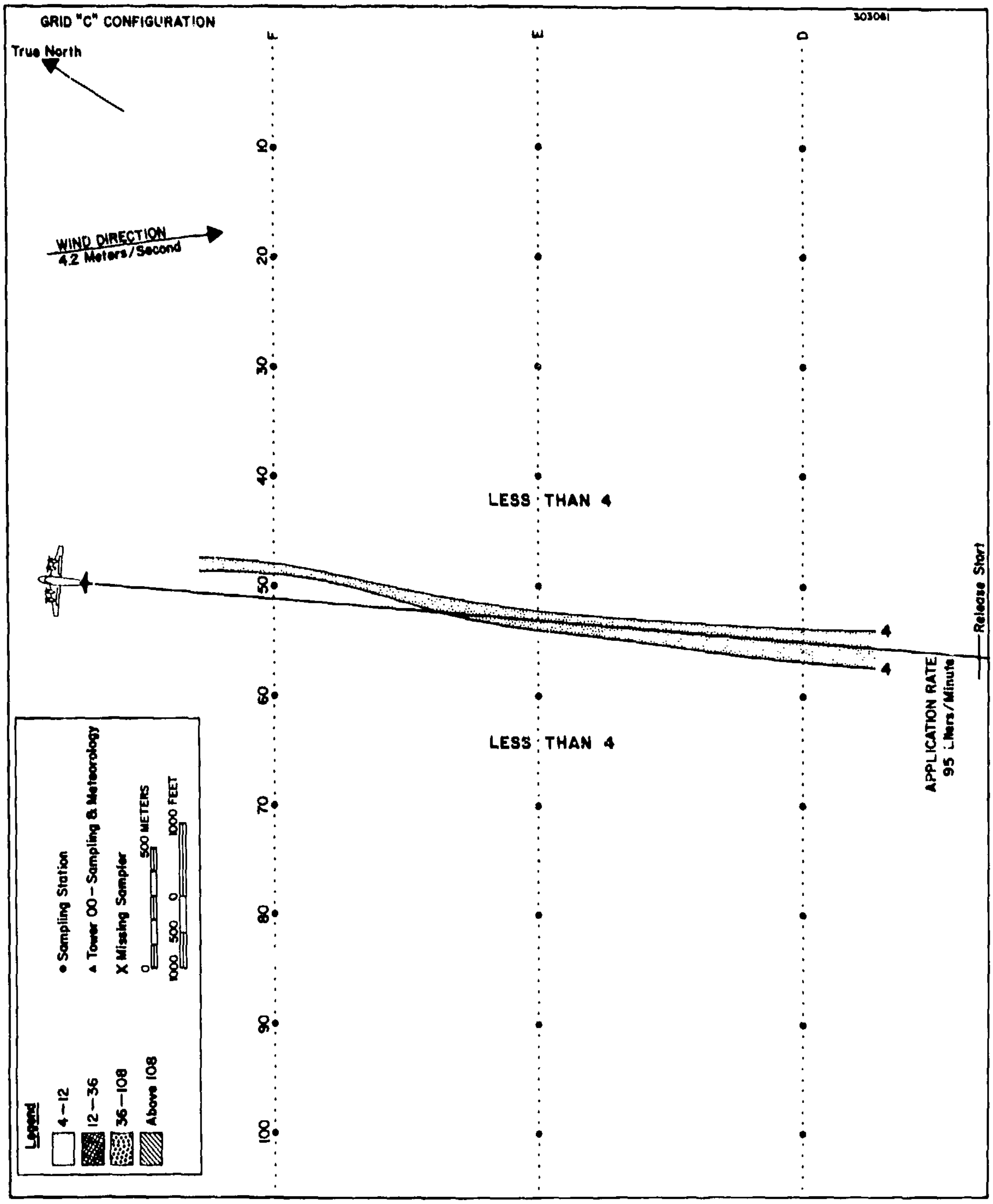


Figure 4-13 Trial 2-3 Mass Density Patterns. The values shown are the mass in milligrams per square meter. Shaded areas indicate coverage for the range shown.

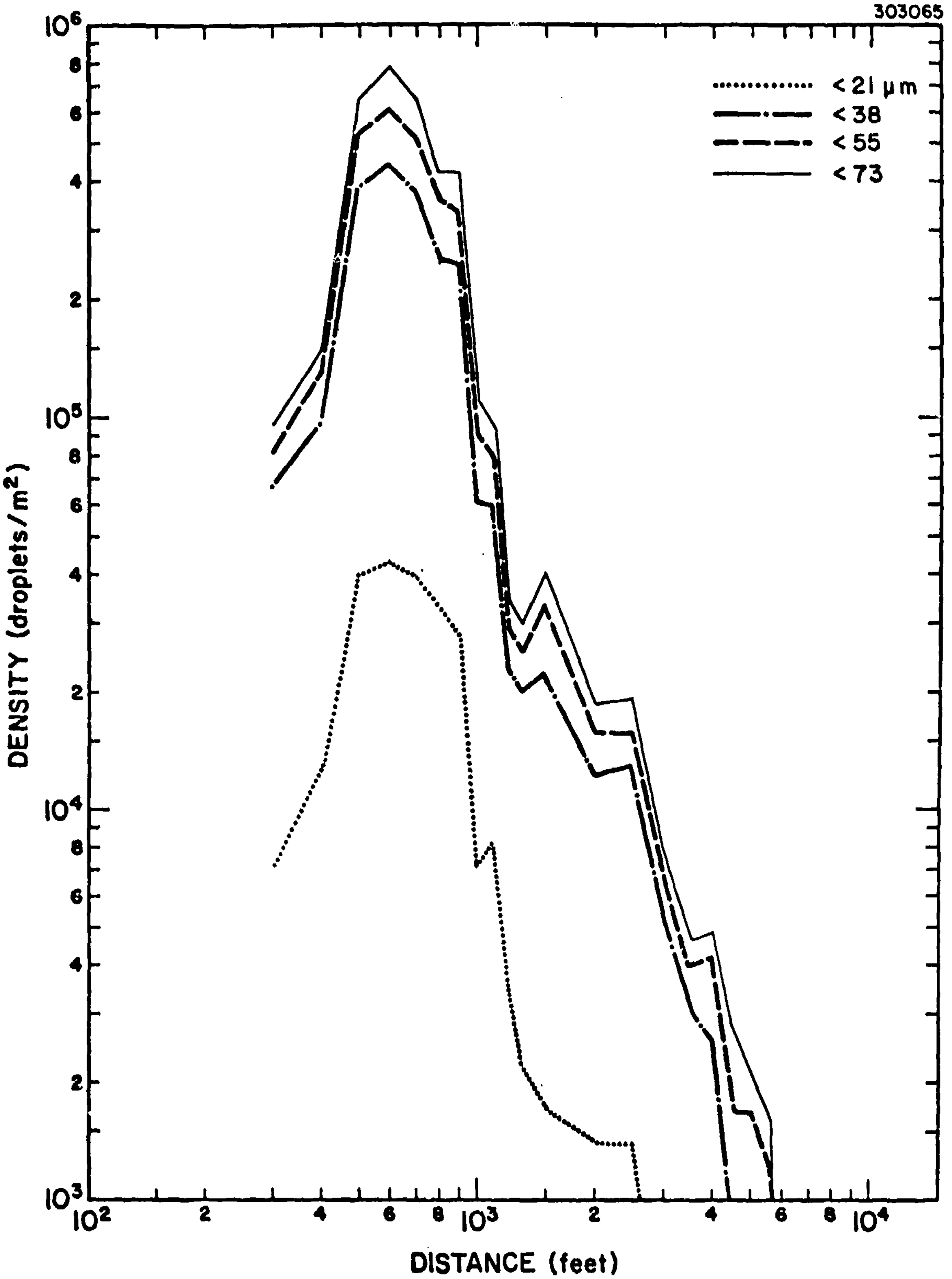


Figure 4-14. Trial 1-1 Droplet Deposition Density. The lines shown represent the number of droplets per square meter for particles <21 μm, <38 μm, <55 μm, and <73 μm.

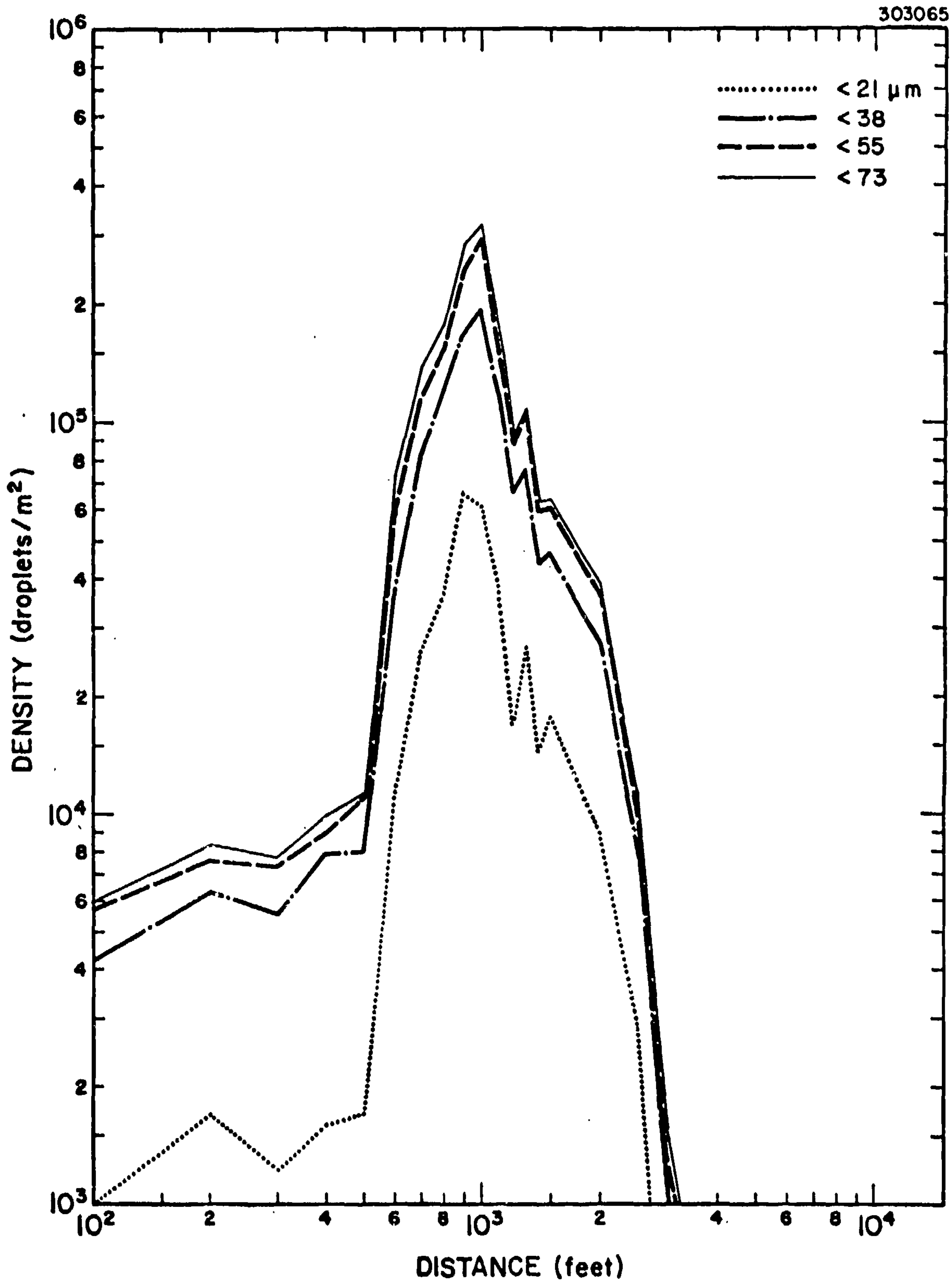


Figure 4-15 Trial 1-2 Droplet Deposition Density. The lines shown present the number of droplets per square meter for particles <21 μm, <38 μm, <55 μm, and <73 μm.

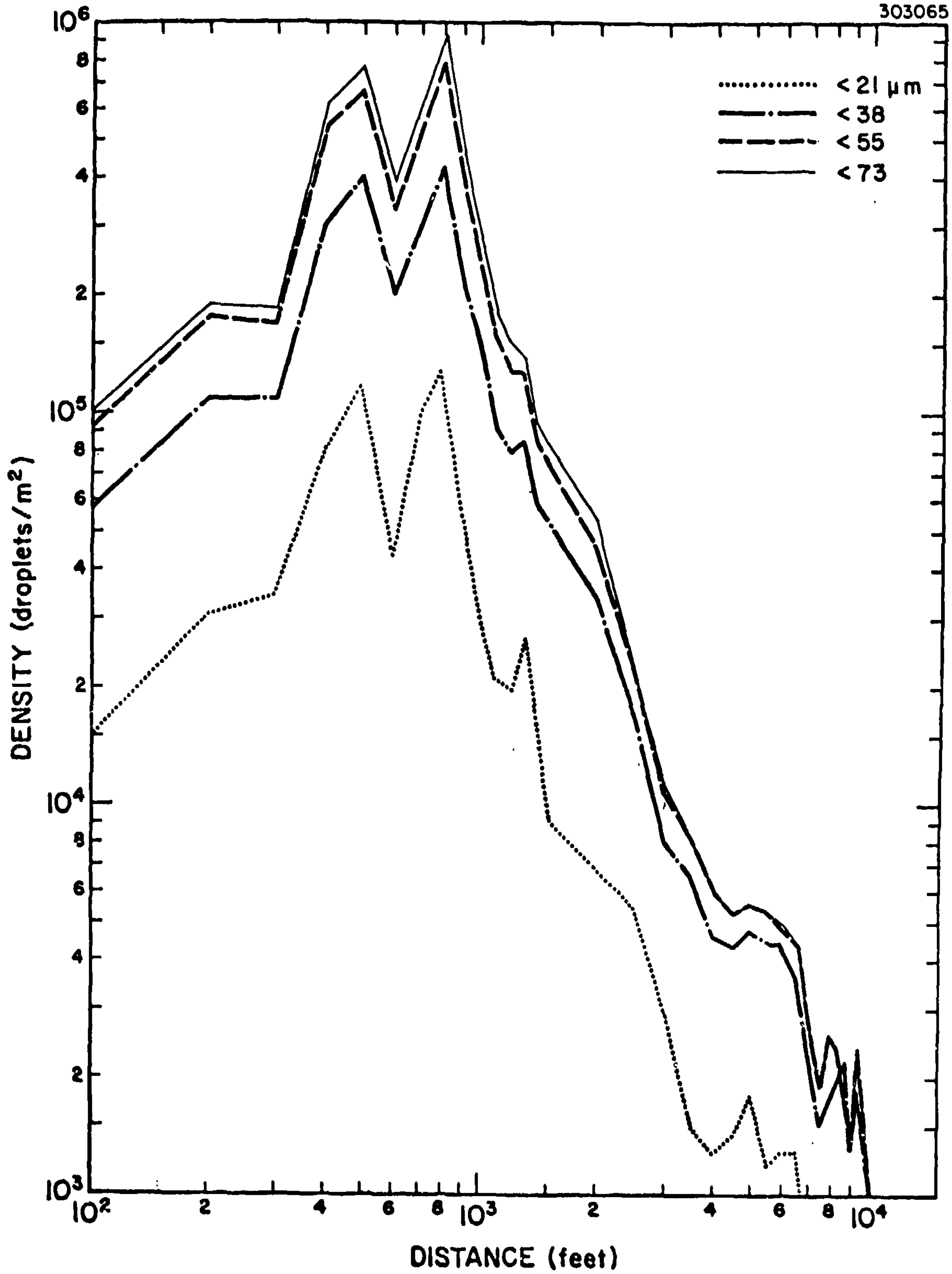


Figure 4-16 Trial 1-3 Droplet Deposition Density. The lines shown present the number of droplets per square meter for particles <21 μm, <38 μm, <55 μm, and <73 μm.

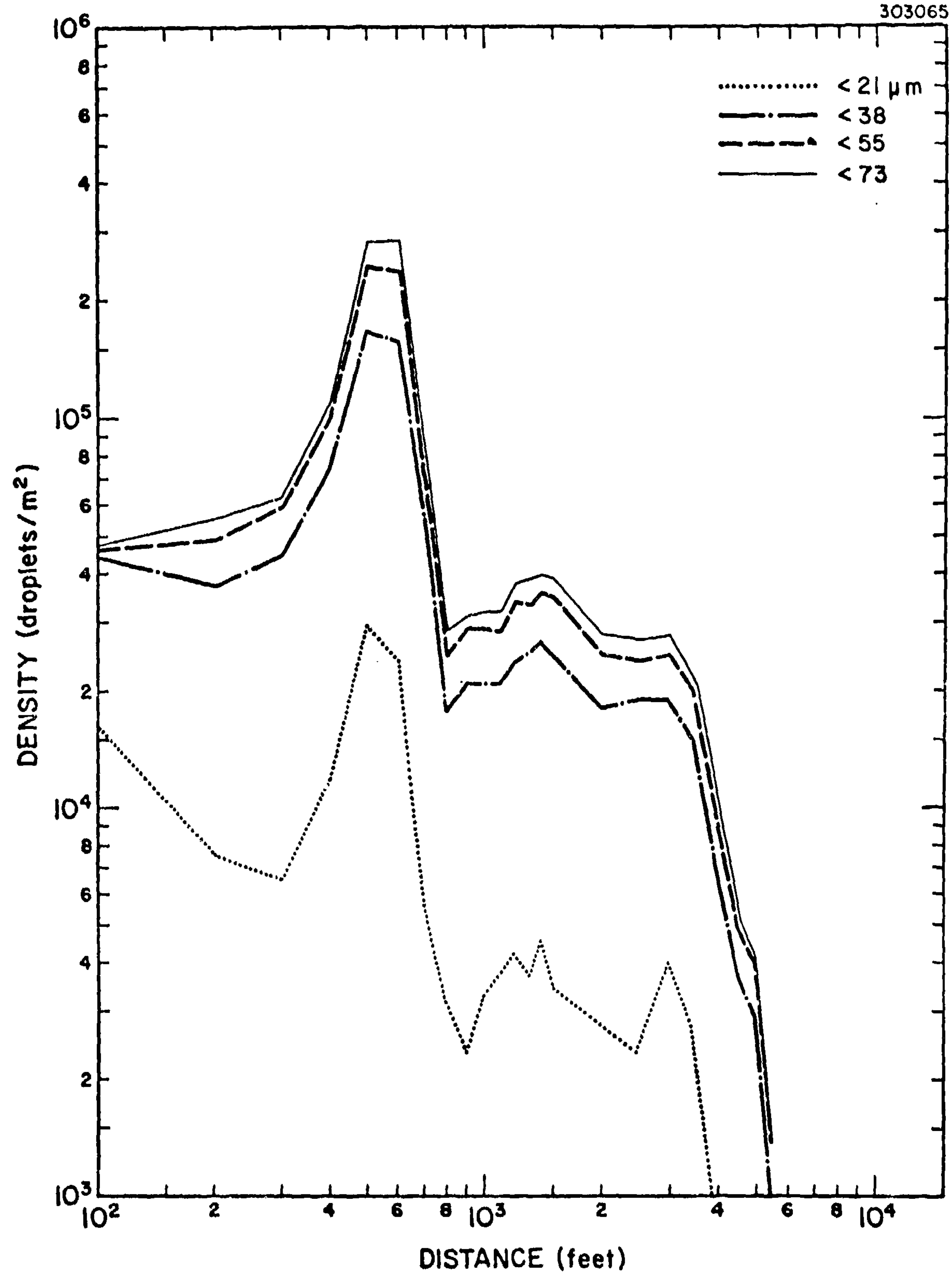


Figure 4-17 Trial 1-4 Droplet Deposition Density. The lines shown present the number of droplets per square meter for particles <21 μm, <38 μm, <55 μm, and <73 μm.

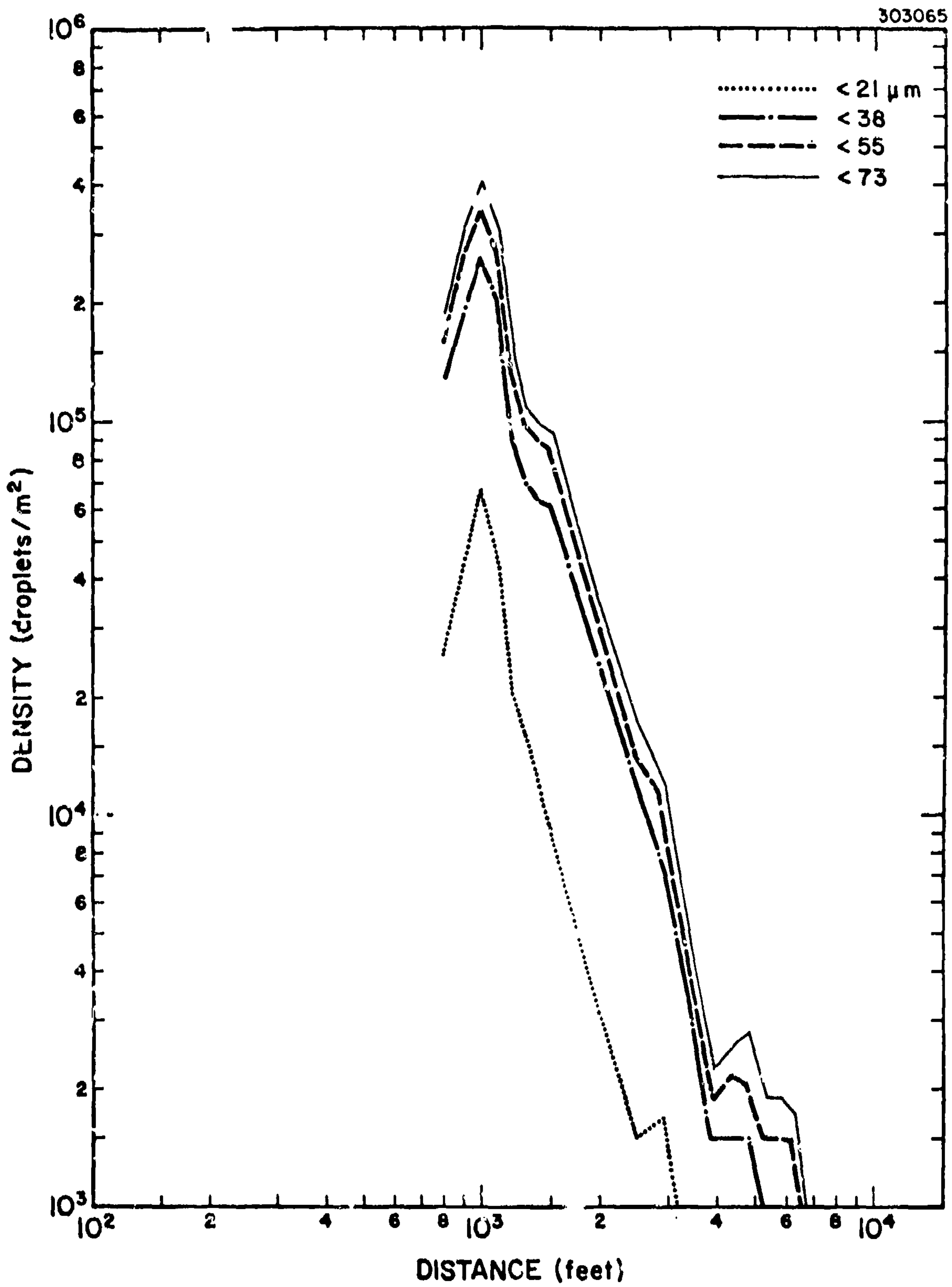


Figure 4-18 Trial 1-5 Droplet Deposition Density. The lines shown present the number of droplets per square meter for particles <21 μm, <38 μm, <55 μm, and <73 μm.

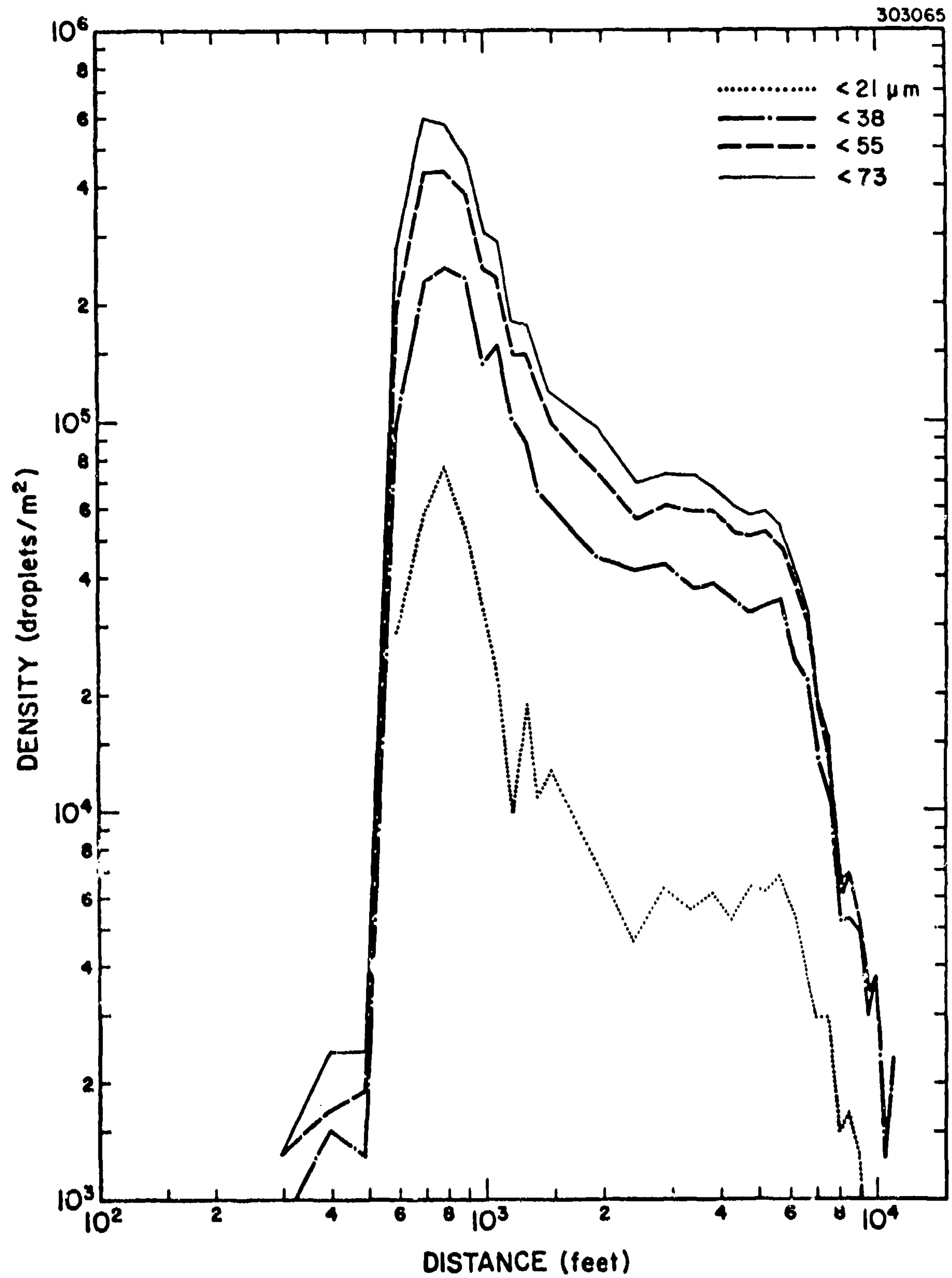


Figure 4-19 Trial 1-6 Droplet Deposition Density. The lines shown present the number of droplets per square meter for present <21 μm, <38 μm, <55 μm, and <73 μm.

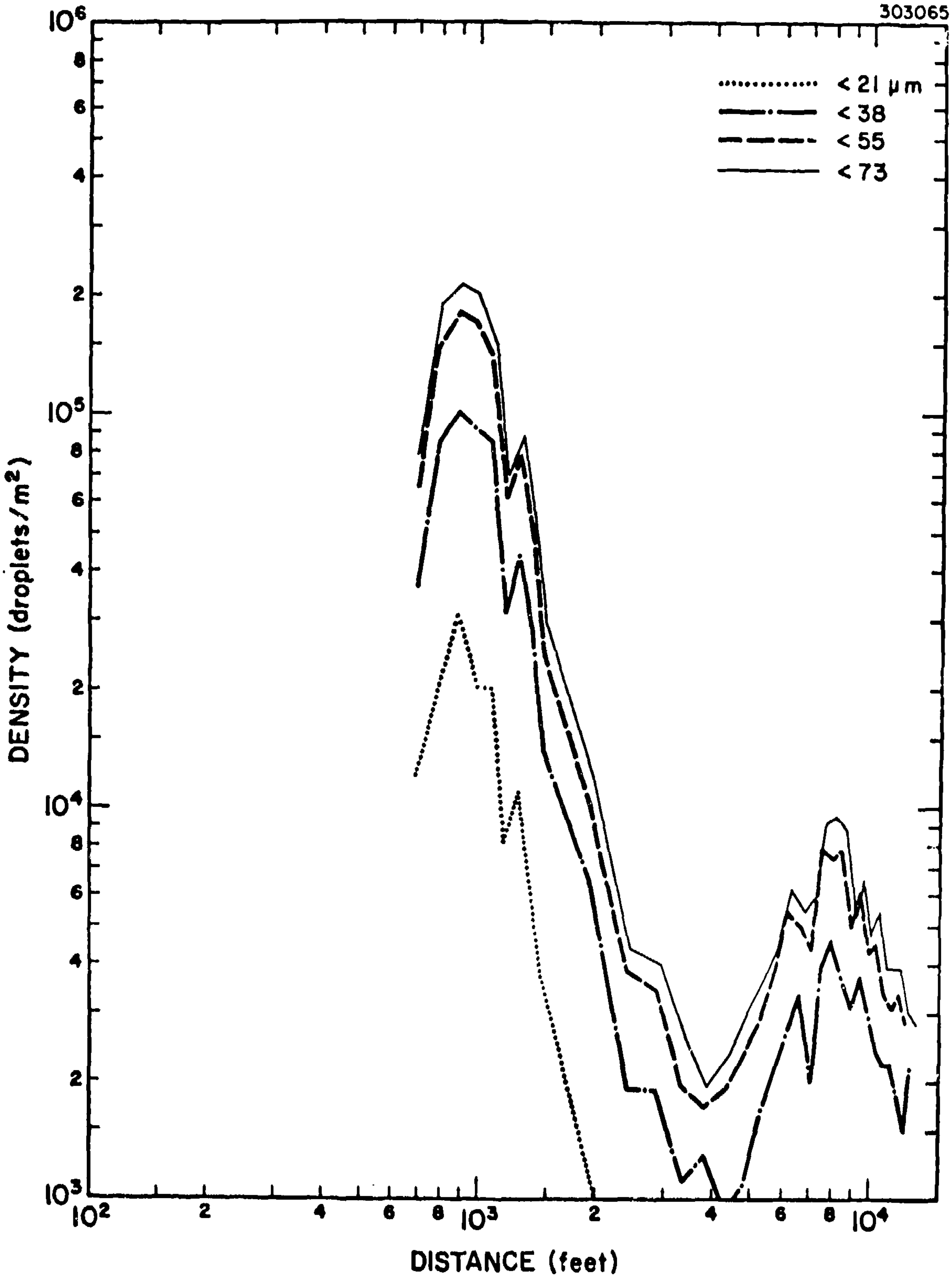


Figure 4-20 Trial 1-7 Droplet Deposition Density. The lines shown present the number of droplets per square meter for present <21 μm, <38 μm, <55 μm, and <73 μm.

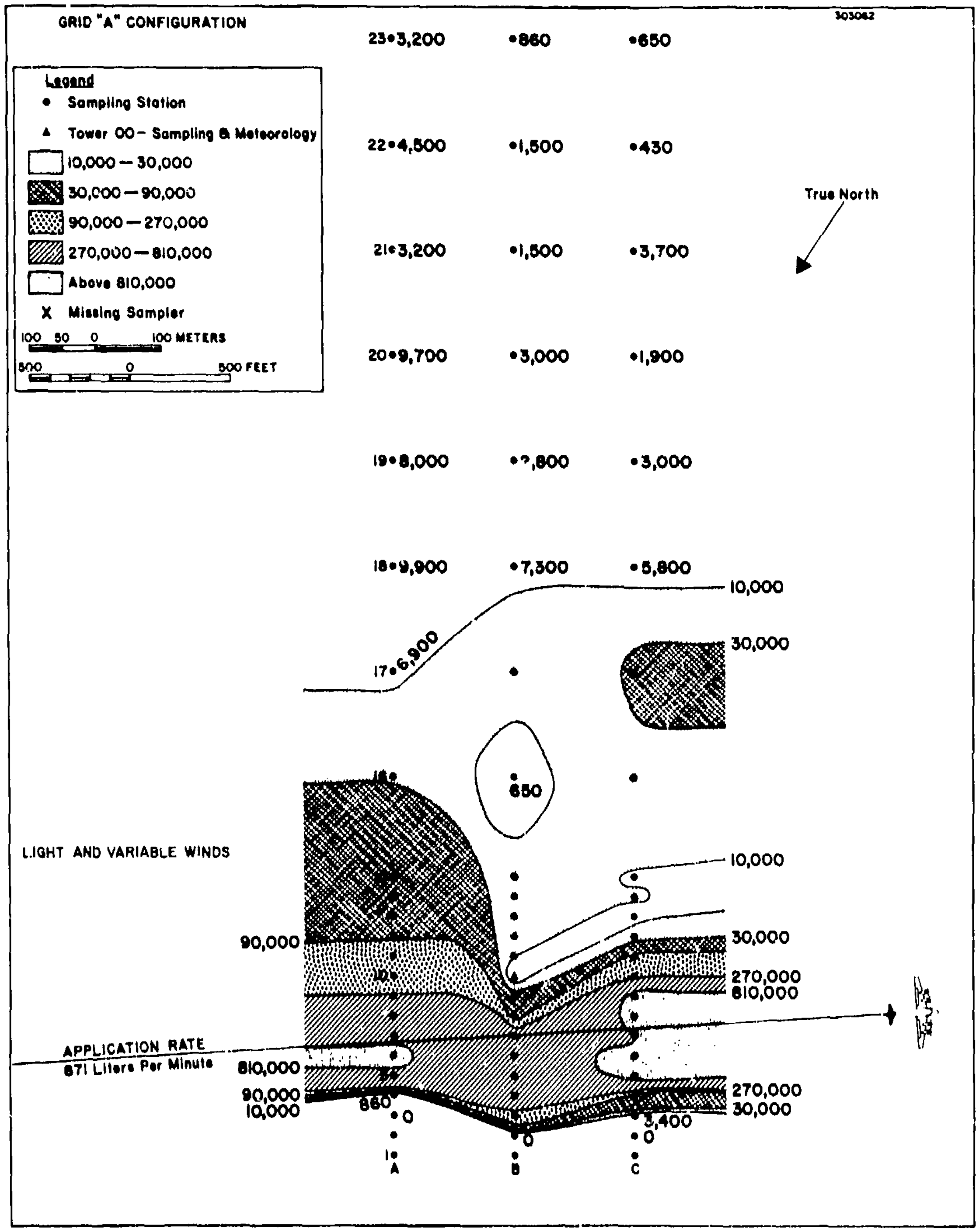


Figure 4-21 Trial 1-1 Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

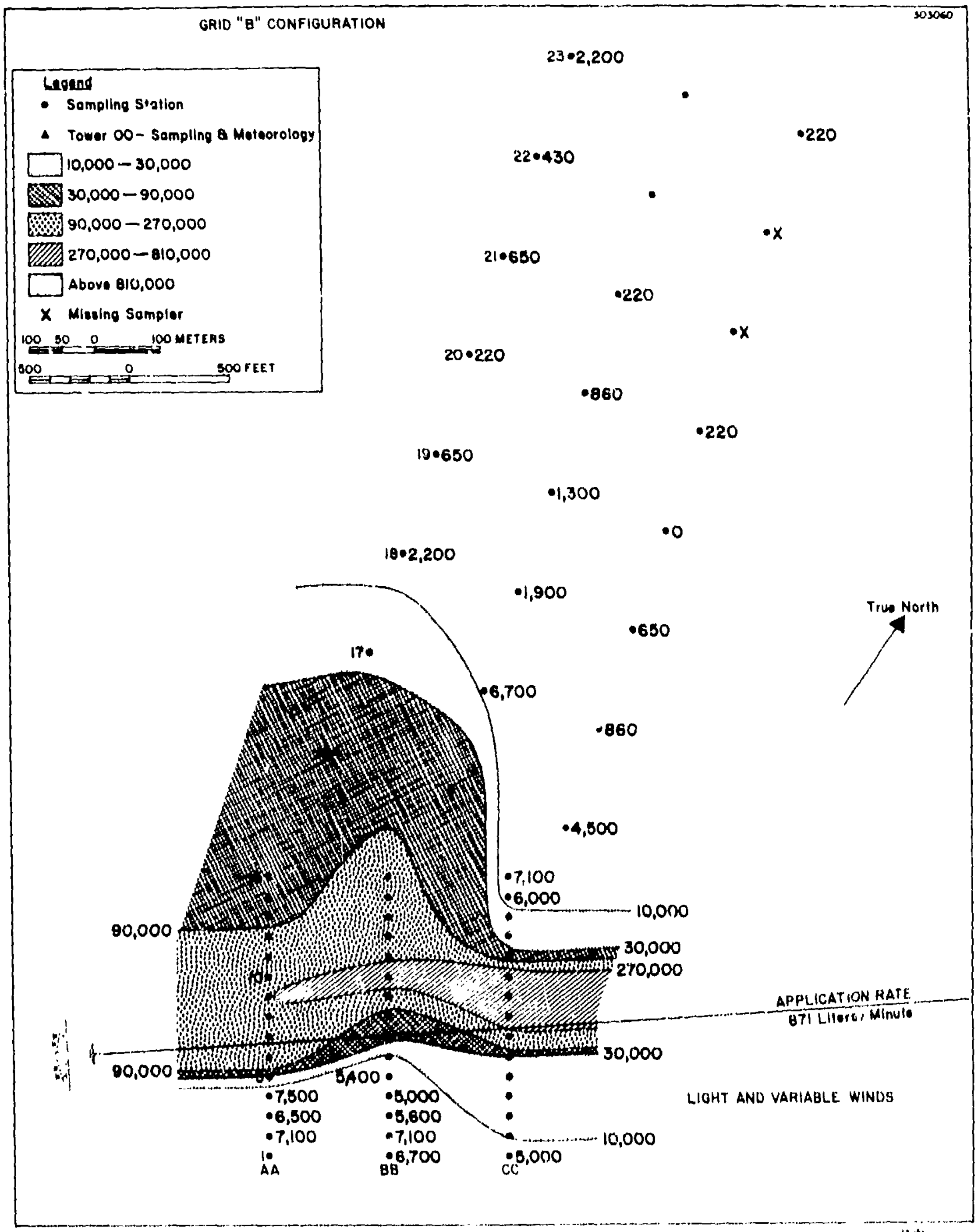


Figure 4-22 Trial 1-2 Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

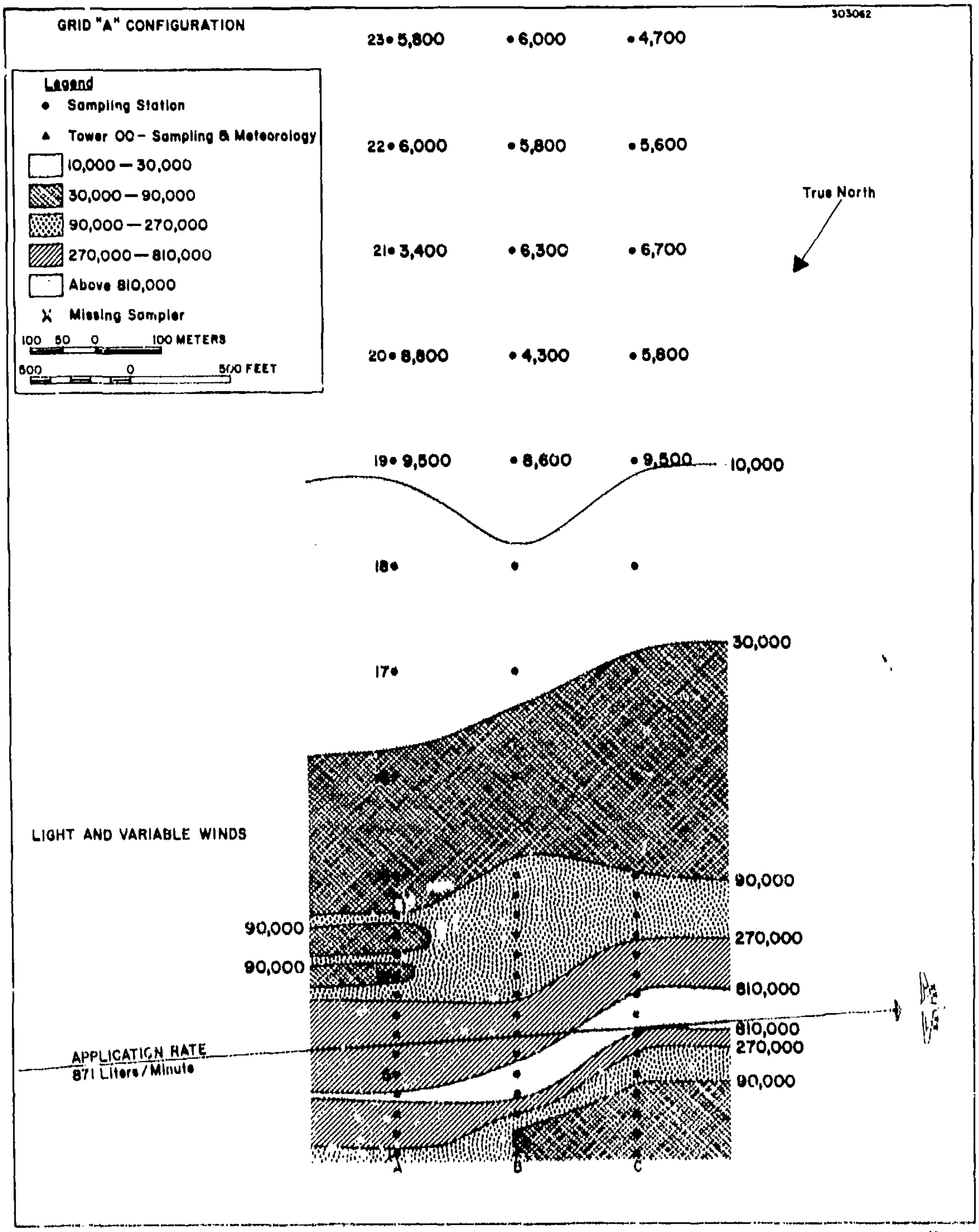


Figure 4-23 Trial 1-3 Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

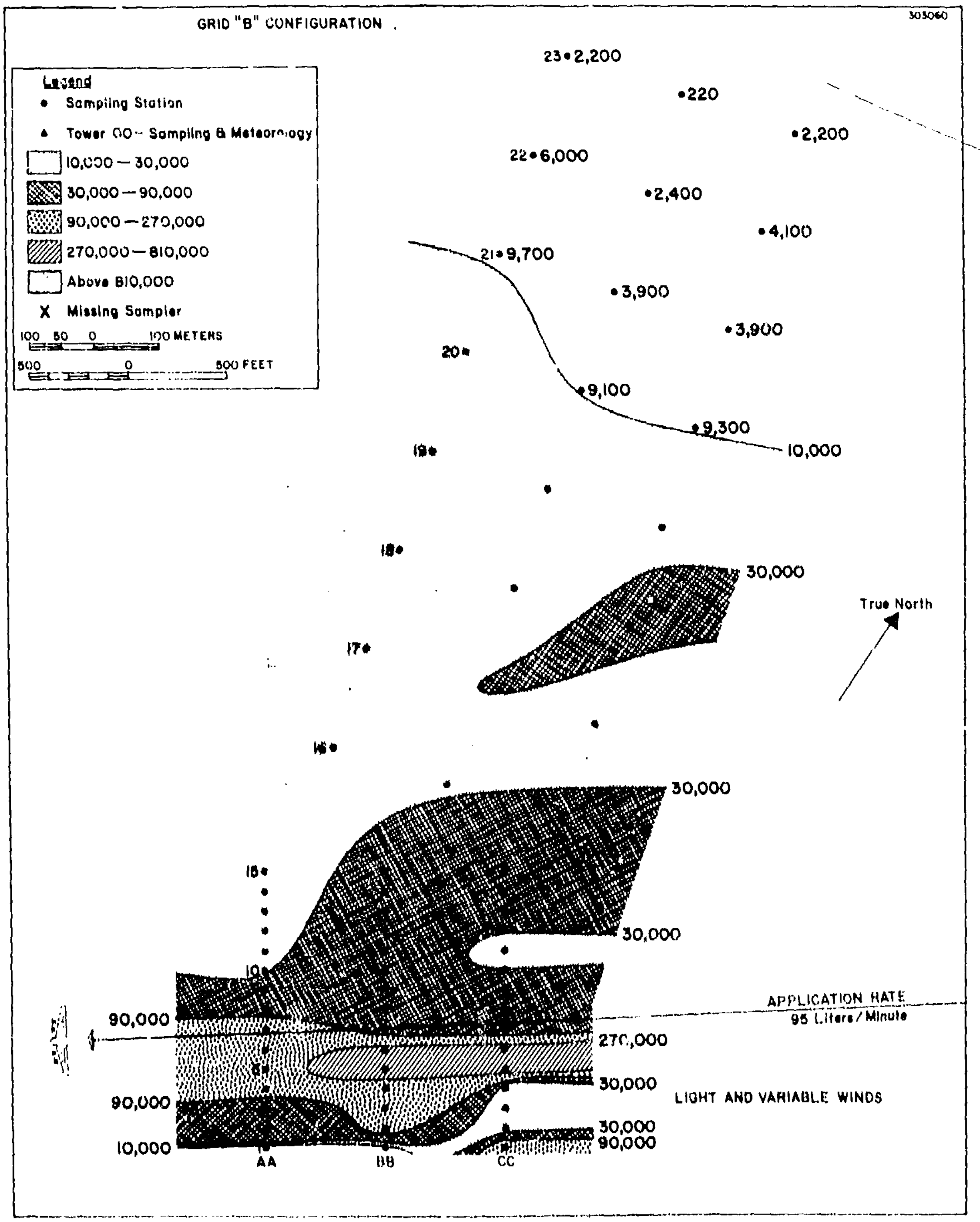


Figure 4-24 Trial 1-4 Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

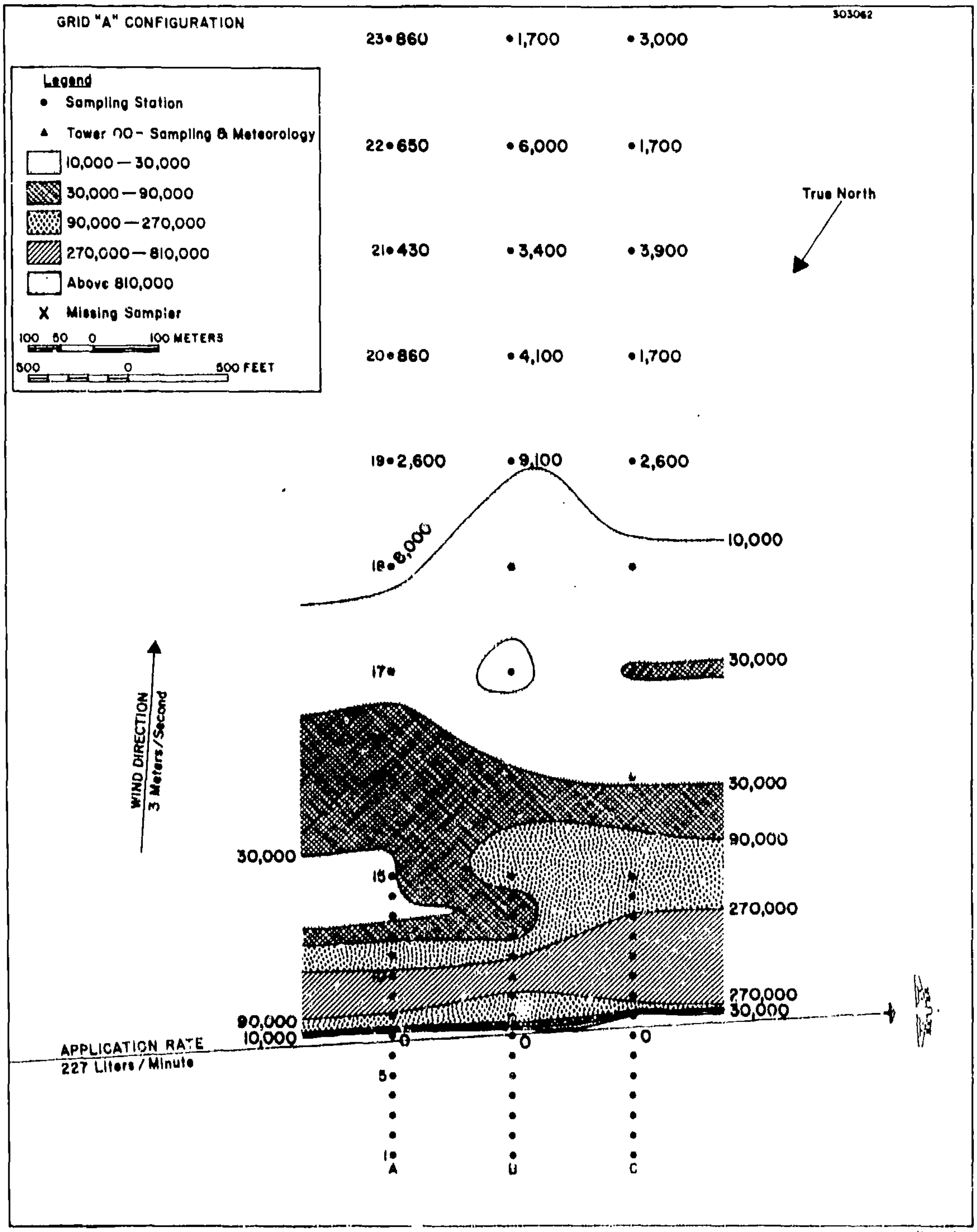


Figure 4-25 Trial 1-5 Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

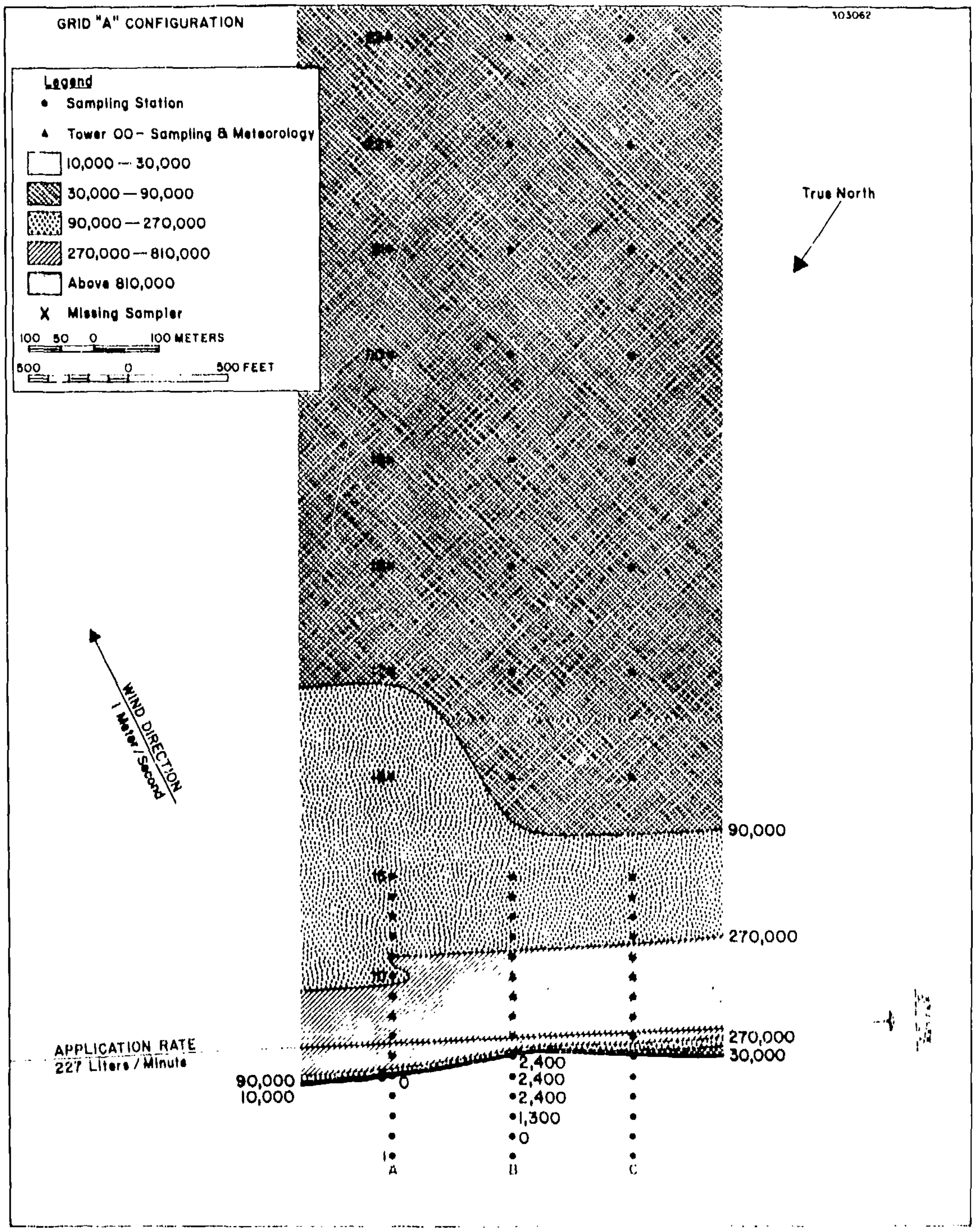


Figure 4-26 Trial 1-6 Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

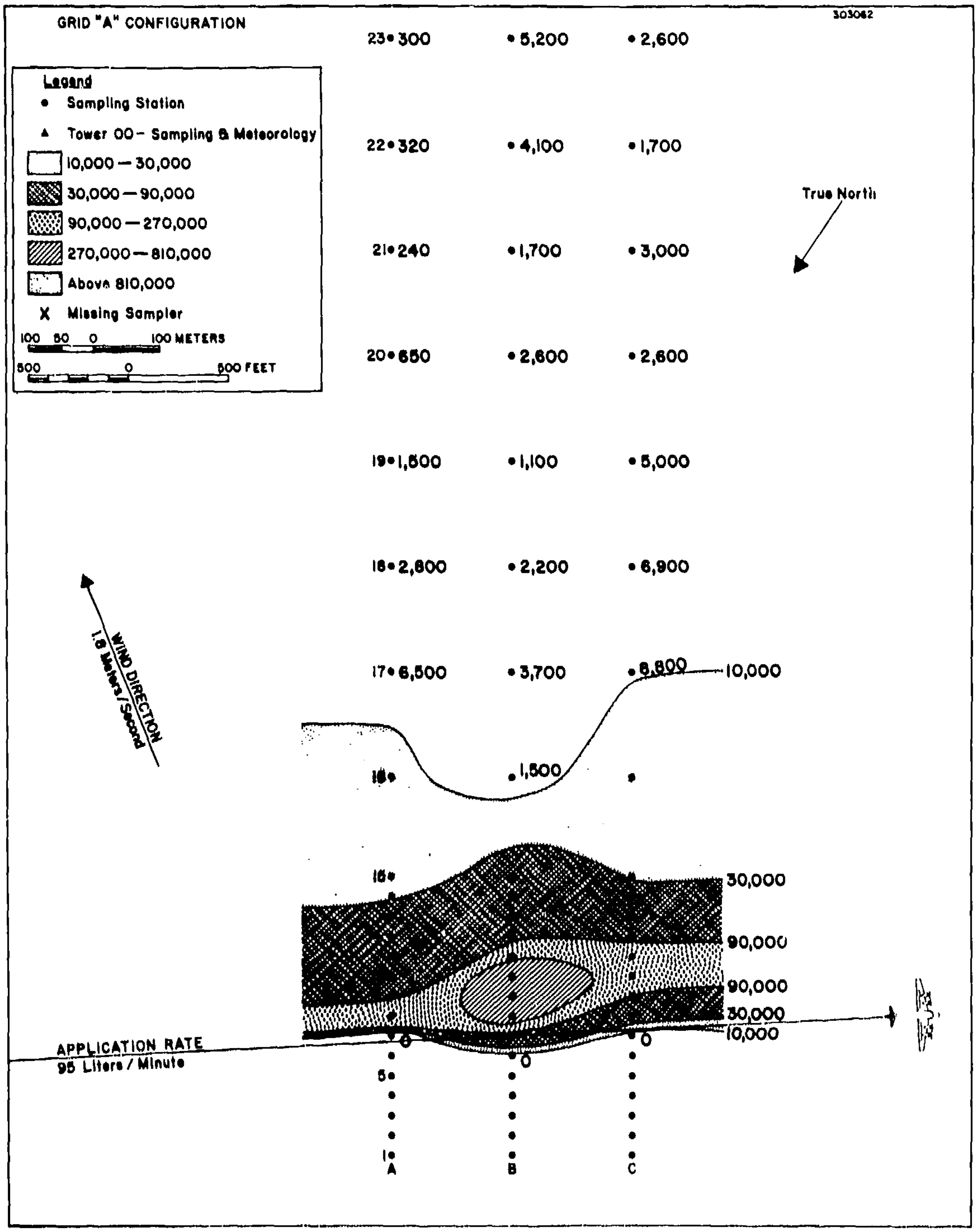


Figure 4-27 Trial 1-7 Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

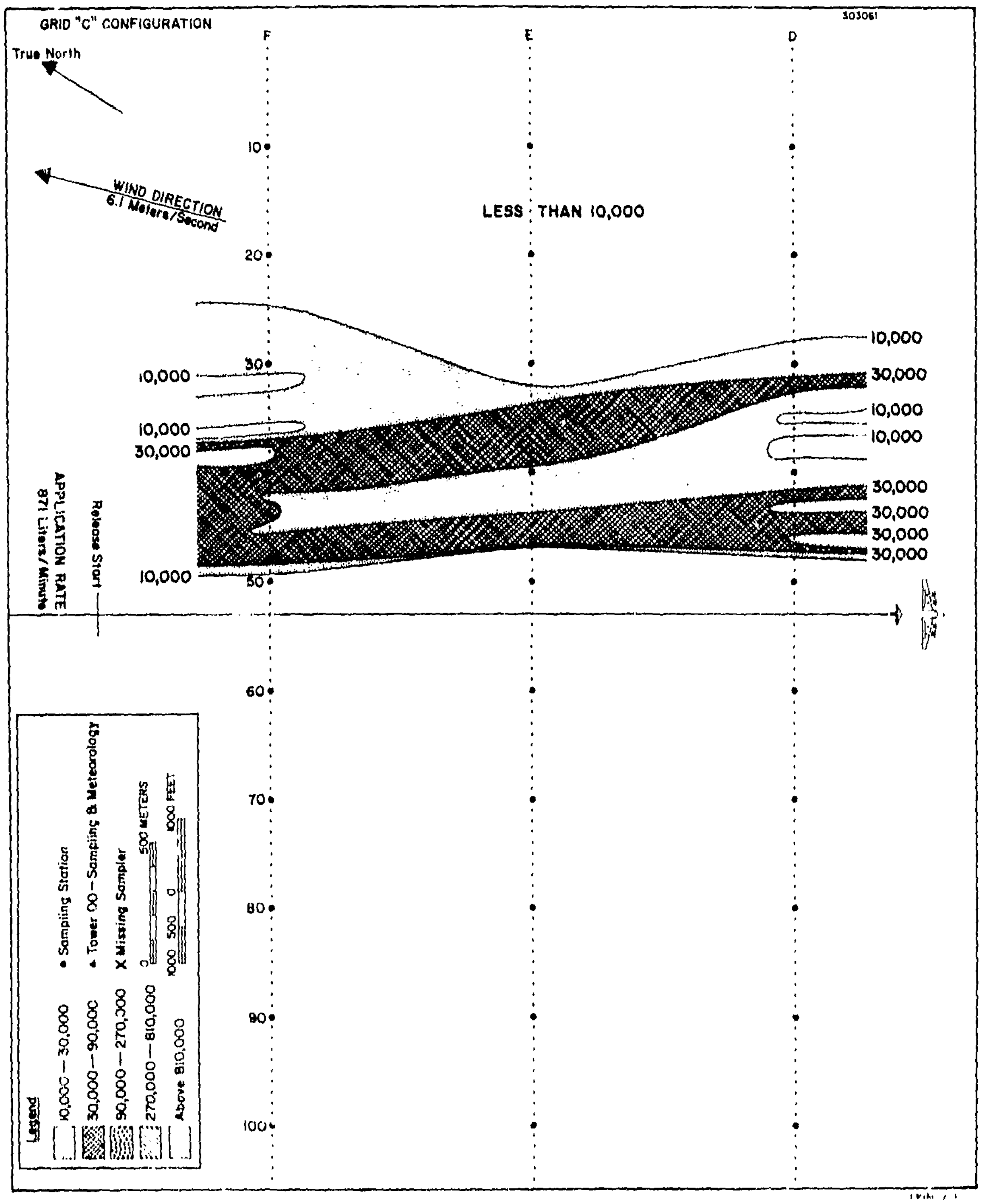


Figure 4-28 Trial 2-1 Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

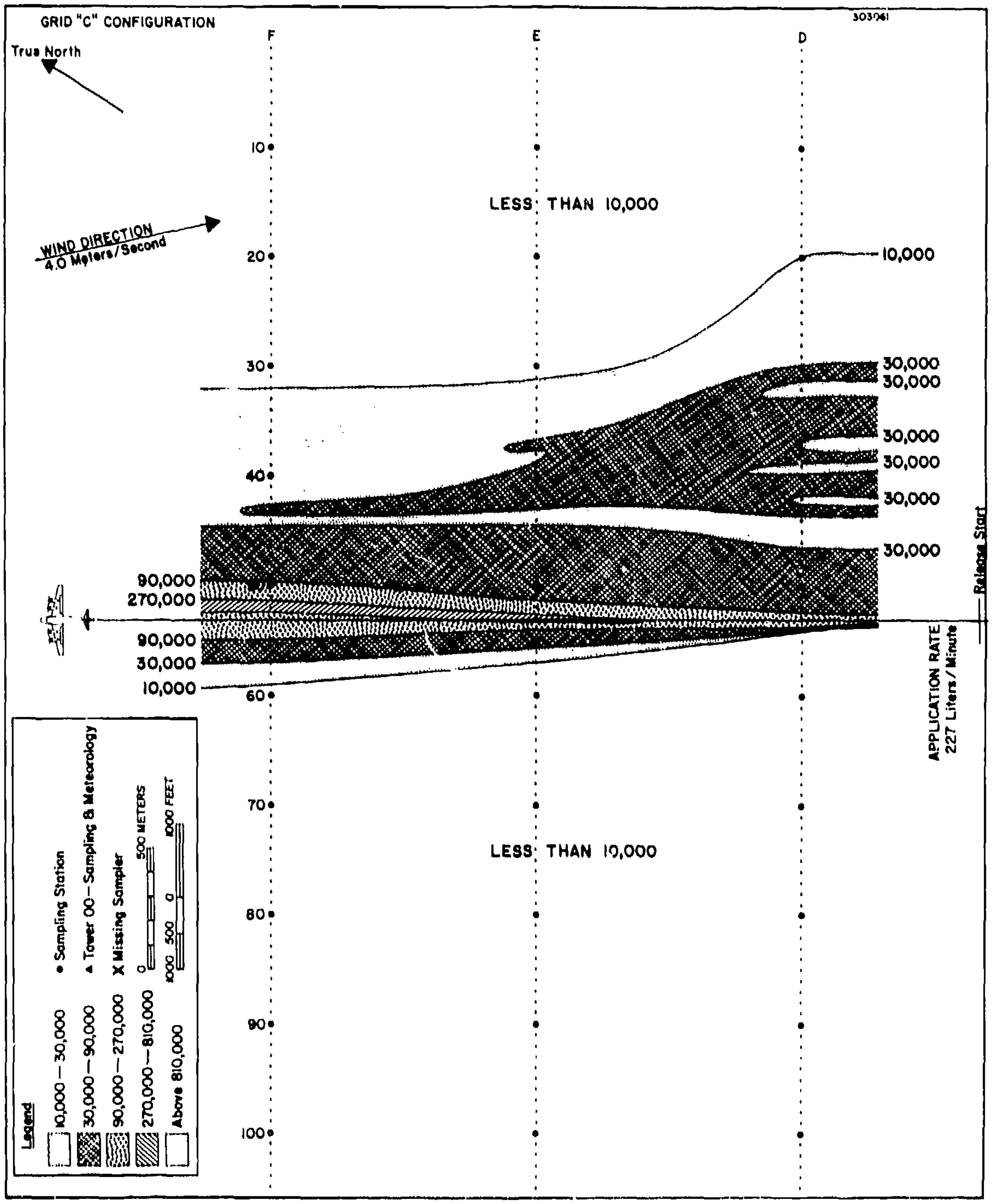


Figure 4-29 Trial 2-2R Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

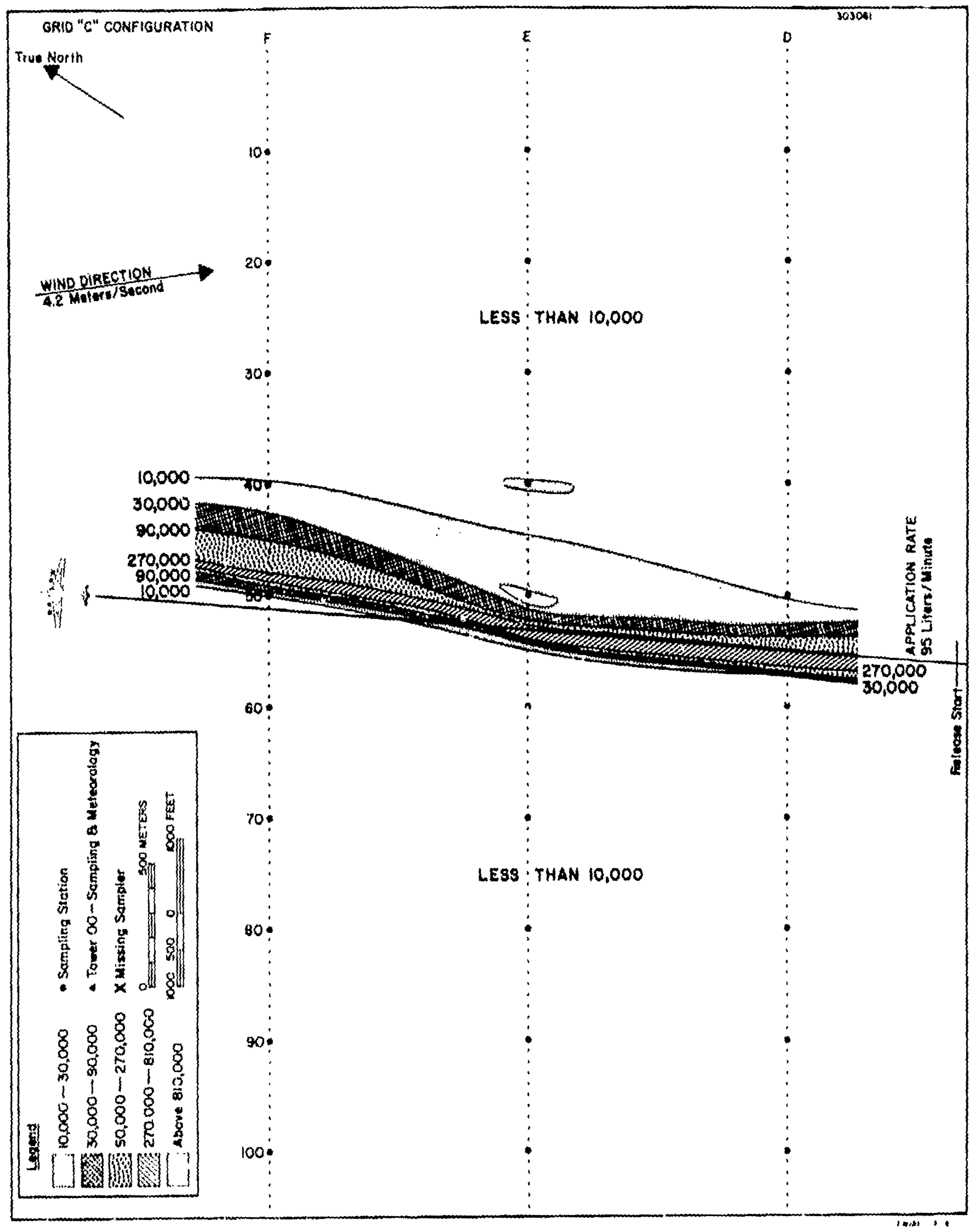


Figure 4-30 Trial 2-3 Droplet Deposition Pattern. The values shown are the total number of droplets (dia. <73 μm) per square meter. Shaded areas indicate coverage within ranges shown.

(<10μm) are assumed to behave as a gas, the particles are not deposited on the ground in the release area but are rendered ineffectual in the atmosphere by dilution and the physical phenomena of nature. For these reasons, it is very unlikely that a complete accountability of material released (mass balance) can be obtained on the horizontal sampling grids used for these trials. Additional trial data might have permitted a more valid estimate of mass accountability and with a satisfactory model, off-grid quantities could have been obtained to establish a mass balance of material.

The grids for these trials are shown in Figures 4-1, 4-2 and 4-3. At each sampling point, a Printflex card was placed (horizontal) on the ground for deposition sampling. The sampling area of the Printflex card was 308 square centimeters. Each Printflex card was assigned an area of responsibility (a horizontal area assumed to have the same deposition density as the Printflex card).

In this test, the grid can be generally described as three parallel lines. The area of responsibility for each Printflex card was a rectangle. The length (L) is calculated by the following expression:

$$\frac{d_{i+1}-d_{i-1}}{2} = l_i$$

where d is distance measured along the parallel sampling lines, i is the sequentially numbered station, and width is 1 meter. The choice of width is arbitrary as long as the release length and width of the rectangle are identical. The area dosage products are summed over the length of the line, and estimates made of the mass of material accounted for by the sampling network.

4.3 VERTICAL RECOVERIES

4.3.1 Efficiency Estimates from a Single Vertical Tower

The following describes a technique for estimating the efficiency of a continuous generator when employed in a long line release of material using a vertical array of samplers on a single tower.

4.3.2 Mathematical Development of Model

Consider an infinitely small cube of cloud with a concentration of C grams per unit volume, having dimensions dx, dy, and dz. The quantity of materials dq in the cube is

$$dq = C dx\, dy\, dz \qquad (1)$$

Alternately, consider a fixed vertical plane at an arbitrary downwind distance x_1 and normal to the wind vector. The amount of material passing through an area element (dy, dz) of the plane in time dt is

$$dq = u_{(y,t,z)} \, C_{(y,t,z)} \, dydtdz \qquad (2)$$

where u is the transport wind speed.

The total amount of material is

$$q = \iiint_{zty} u_{(y,t,z)} \, C_{(y,t,z)} \, dydtdz \qquad (3)$$

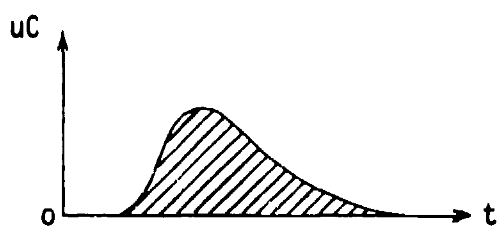
If C and u are both independent of y, then over a specified cross wind strip $-L/2 \leq y \leq L/2$, the total amount of material is

$$q = \iint_{zt} u_{(t,z)} \, C_{(t,z)} \int_{-L/2}^{L/2} dydtdz$$

where L is a specified length of release line

$$q = L \iint u_{(t,z)} \, C_{(t,z)} \, dtdz \qquad (4)$$

In the field operation, the sampling period encompasses the entire passage time of a cloud. The total dosage collected by the



Thus, the total dosage at height z is

$$D_{(z)} = \int_0^t u_{(t,z)} \, C_{(t,z)} \, dt \qquad (5)$$

assuming that the sampling device is operated long enough to sample the entire cloud.

Substituting Equation 5 into Equation 4 gives

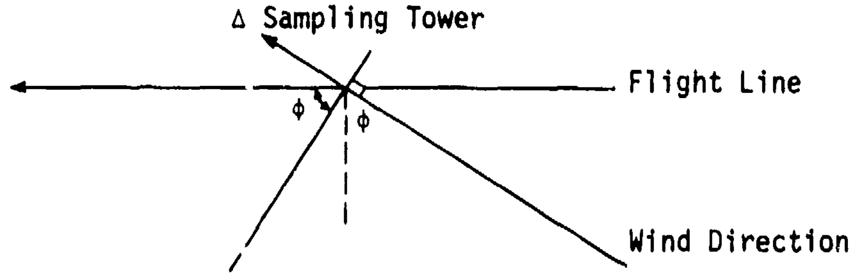
$$q = L \int_0^\infty D_{(z)} dz \qquad (6)$$

The output or effective line source strength is represented by the summation

$$q = L\sum_{i=1}^{n} D_i \Delta h_i \qquad (7)$$

where i indicates the i-th sampling height and Δh_i is the height interval assigned to a sampling station at height i.

If the flight path is not normal to the transport wind direction, the flux density of the material is increased as it travels past the sampling tower. This is illustrated below:



where ϕ is the angular deviation of the flight line from normal to the wind direction. It is assumed that wind direction is constant over the entire height range.

The appropriate correction is achieved by rewriting Equation 1 as

$$q = \left(L \sum_{i=1}^{n} D_i \Delta h_i\right) \cos \phi \qquad (8)$$

The input source strength or amount of material disseminated Q is determined by

$$Q = rL$$

where r is the rate of dissemination and L is a dissemination length which must be the same as used in q.

Any system of consistent units may be used. In this test, the units were

q (grams) = L(meters) D(grams/meter^2) h(meters)

Q (grams) = r(g/m) L(m)

Efficiency (E) is then determined by dividing the output value obtained from Equation 8 by the input source factor, Equation 9 and multiplying by 100. Thus

$$E = 100\ q/Q$$

The above technique assumes the following conditions:

a. The entire vertical dimension of the cloud is contained in the vertical sampling array.

b. The dissemination line is long enough and placed so that no edge effects exist.

c. The rate of release is uniform and known for the portion of cloud sampled.

Lack of the first two conditions will result in underestimates of efficiency. If the third condition is not met, then the variability of efficiency is increased, and a valid estimate of efficiency can be made only from a large number of trials with selected portions of release line sampled.

4.3.3 Method for Estimating Source Strength and Efficiency

1. Estimate q, the amount of material accounted for by the vertical sampling array:

a. Transform the sampler recoveries at each level to D_i values. The sampling on the vertical tower was accomplished using pipe cleaners with a sampling area of 4.5403 square centimeters per pipe cleaner. Five samplers were set up at each level. The dye from the five samplers was extracted with 15 milliliters of isopropyl alcohol and the resulting sample assayed by the spectrophotometric method. The Endosulfan from the pipe-cleaner samplers was extracted into 10 milliliters of heptane and the resulting sample assayed with the gas chromatograph. The laboratory reported the concentration values in gamma per milliliter. The dimensional model for converting to grams per square meter is

$$\frac{(\gamma/\text{ml})\ (\text{ml})\ (\text{g}/\gamma)}{(\text{cm}^2)\ (\text{m}^2/\text{cm}^2)} = \text{g/m}^2 \text{ of dye or Endosulfan}$$

The conversion constants of 6.607×10^{-3} or 4.405×10^{-3} for dye and Endosulfan, respectively, multiplied by the laboratory value in γ/ml yield D_i in g/m^2.

b. Assign an area of responsibility to each D_i value. The length factor (L) can be arbitrarily chosen as the length of release line or another distance of choice; for convenience, L is usually chosen as 1 meter. The length factor remains the same for all sampling heights (h). The value of Δh_i is usually $(h_{i+1} - h_{i-1})/2$. A modification is made for sample nearest the ground where

$$\Delta h_1 = h_1 + (h_2 - h_1)/2$$

The area of responsibility for each Di is $(L\Delta h_i)$

c. Obtain the total dosage-area products at each level

$$D_i\ (L\Delta h_i) = \text{amount in grams}$$

d. Sum the total dosage area products

$$\sum_{i=1}^{n} Di(L\Delta h_i)$$

e. Multiply $\sum_{i=1}^{n} Di\ (L\Delta h_i)$ by the cosine of the angular deviation of the dissemination line from normal to the wind direction. This gives the output or effective line-source strength q in grams.

$$q = L \cos \phi \sum_{i=1}^{n} D_i \Delta h_i$$

where q is the amount of material accounted for by vertical sampling array.

L is length factor

ϕ is angular deviation of dissemination line from normal to wind direction

D_i is dosage at i-th tower station

h_i is height interval assigned to each i-th tower station

2. Estimate Q input source strength (total amount of material disseminated):

a. Transform the rate in gallons per minute into grams per meter. The information for this conversion is taken from test officer's report, pilot's data sheet, photographic data reduction and the laboratory analysis of the bulk material. The dimensional model for converting to a rate (r) in grams per meter is

$$r = \frac{(\text{gal/min})\ (\text{g}/\ell)\ (\ell/\text{gal})}{(\text{mi/hr})\ (\text{hr/min})\ (\text{m/mi})} = \text{g/m}$$

The conversion constant of 1.411×10^{-1} simplifies the above to

$$\frac{(\text{gal/min})\ (\text{g/}\ell)\ 1.411 \times 10^{-1}}{(\text{mi/hr})} = \text{g/m}$$

b. Account for length of line to be sampled. This length L should be the same as that used previously, paragraph 4.3.3.1.b.

$Q = rL$

where Q is input source strength (total material disseminated)

r is rate in grams per meter

L is length in meters

3. Determine efficiency: divide the output line-source strength q by the input line-source strength Q and multiply by 100.

$E = 100\ (q/Q)$

4.3.4 Vertical Array Estimate of Efficiencies

These trials were conducted in open, flat terrain. The sampling tower is 98 meters high. Samplers were five pipe cleaners placed at each of 46 positions. The positions were at 2-meter intervals from 2 meters to 92 meters above the ground. Two arrays were set up, one on the NE corner of the tower and a second on the SW corner of the tower. Meteorological sensors were placed 2, 16, 32, 64 and 96 meters above the ground.

The material collected on the pipe cleaners asseyed by extracting the Dupont oil red dye in Trials 1-2, 1-3, 1-6, 1-7 and the Endosulfan in Trial 1-5. The concentration of Dupont oil red dye was measured by a spectrophotometer and the concentration of Endosulfan by a gas chromatograph. The chemical assay is covered in detail in Chapter 3.

Each trial is covered separately, with usefulness and limitations cited pertaining to that trial. For each trial, a vertical profile was plotted (Figures 4-31 to 4-35) and the efficiency was calculated (Tables 4-4 to 4-8). These limitations are mainly the result of conducting trials in marginal or no wind conditions. More reliable and accurate results could be expected under an organized wind condition.

4.3.5 Comments on Vertical Efficiency Trials

The UN-FAO representative (Midair Inc) did not provide definitive flow-rate information; therefore, nominal spray system setting estimates were assumed for all trial analyses.

(continued on page 114)

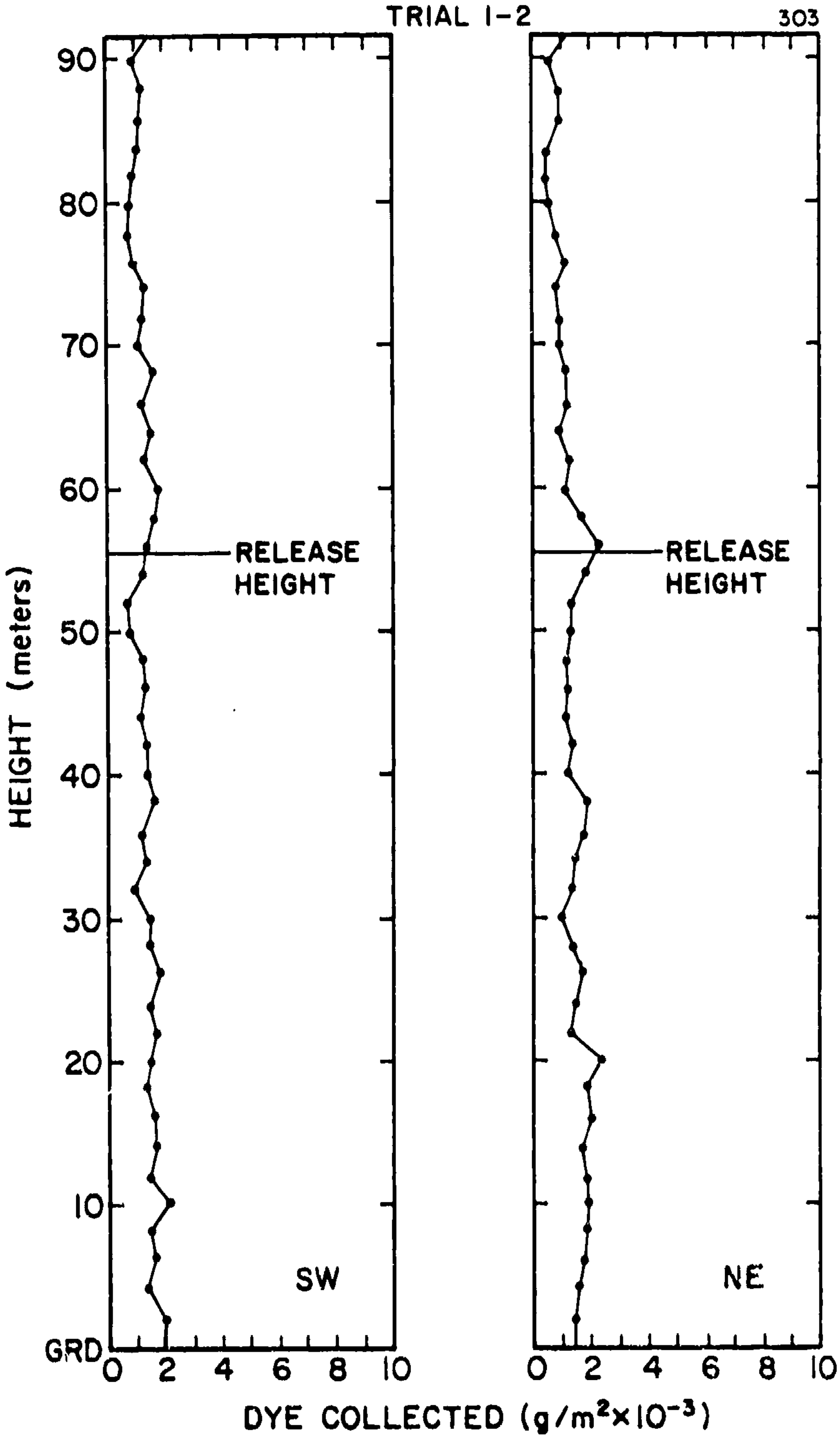


Figure 4-31. Vertical Profile of Dye Collected in Trial 1-2 from Ground Level to 90 Meters

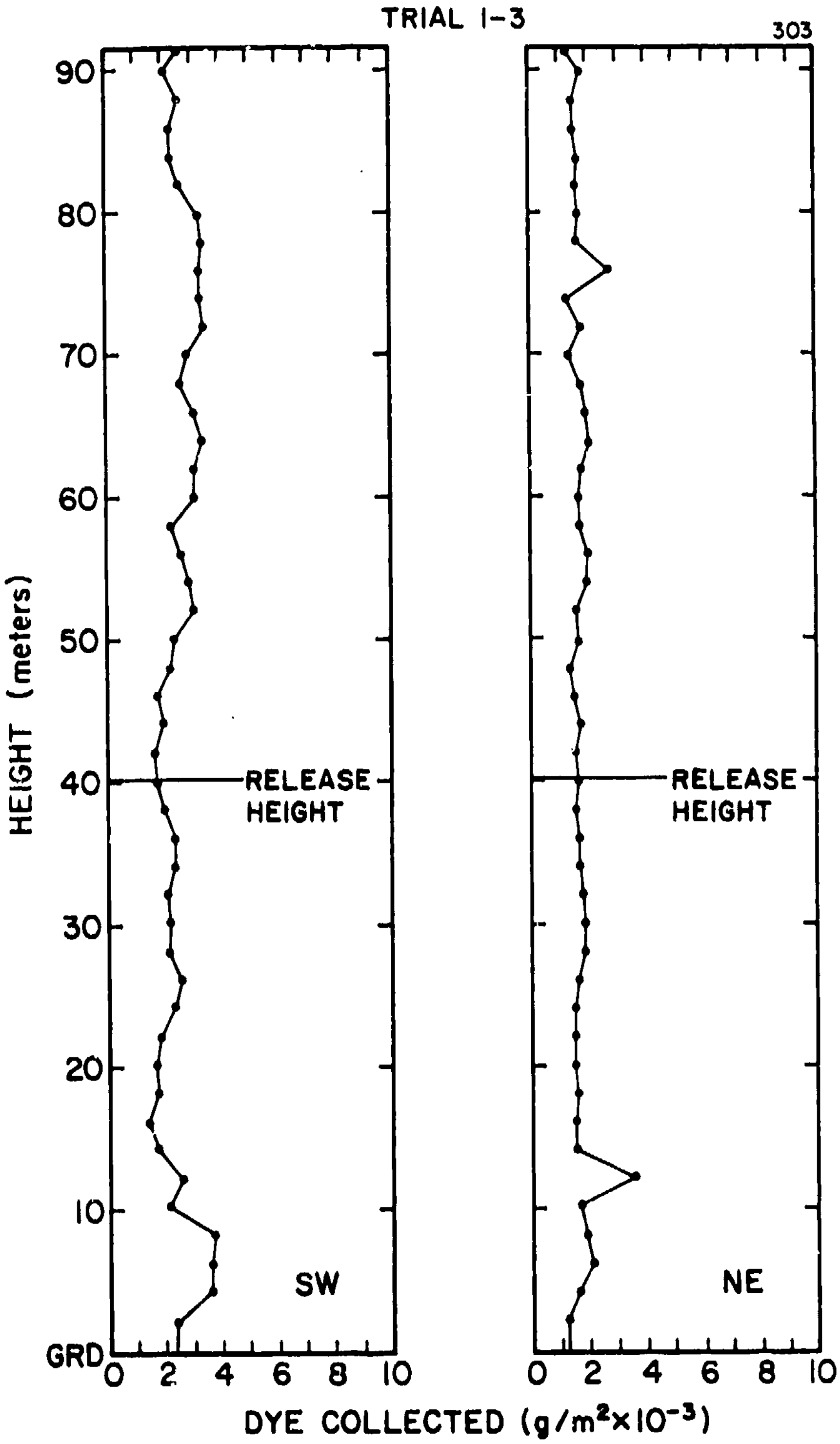


Figure 4-32. Vertical Profile of Dye Collected in Trial 1-3 from Ground Level to 90 Meters

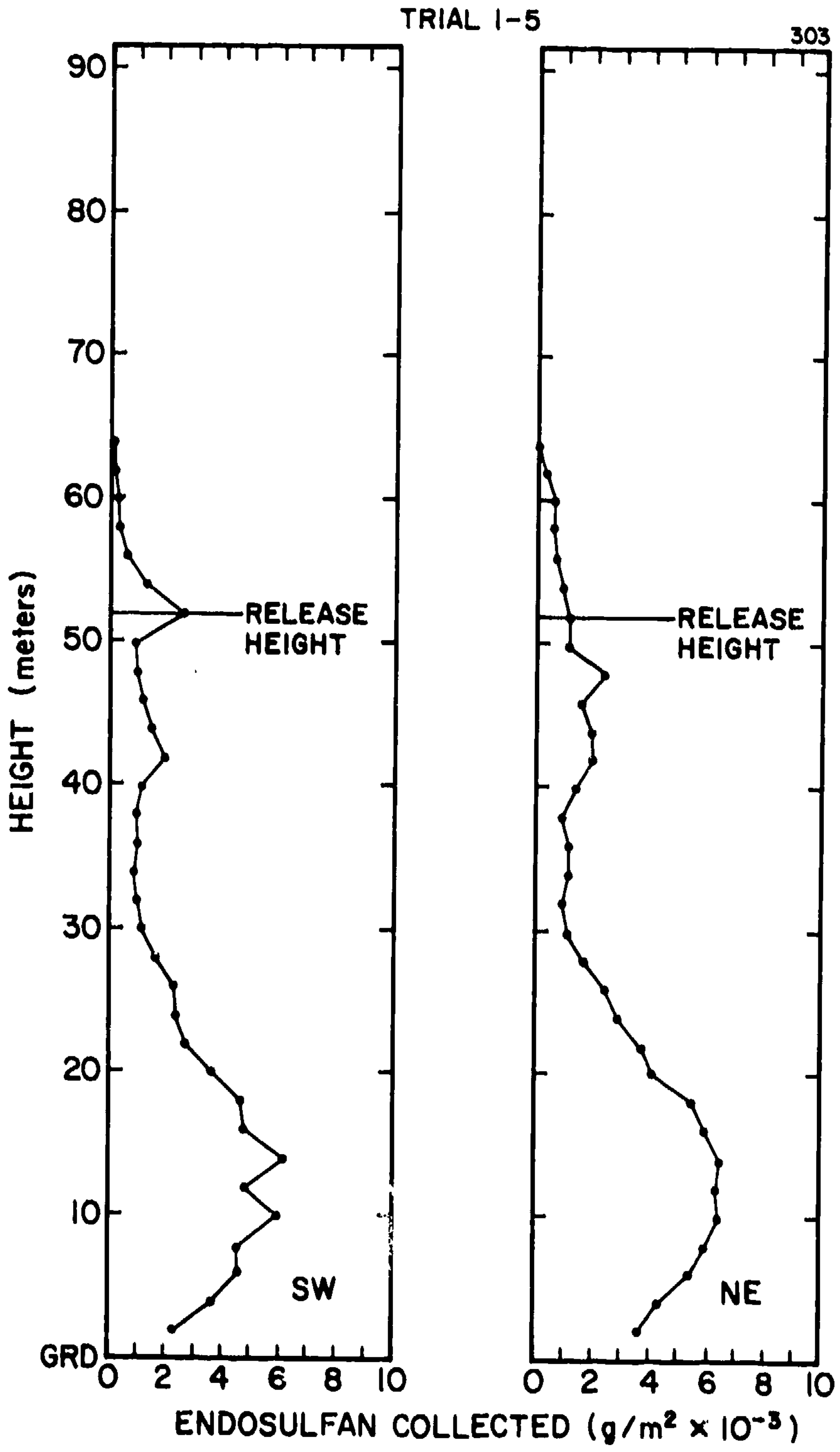


Figure 4-33. Vertical Profile of Endosulfan Collected in Trial 1-5 from Ground Level to 90 Meters

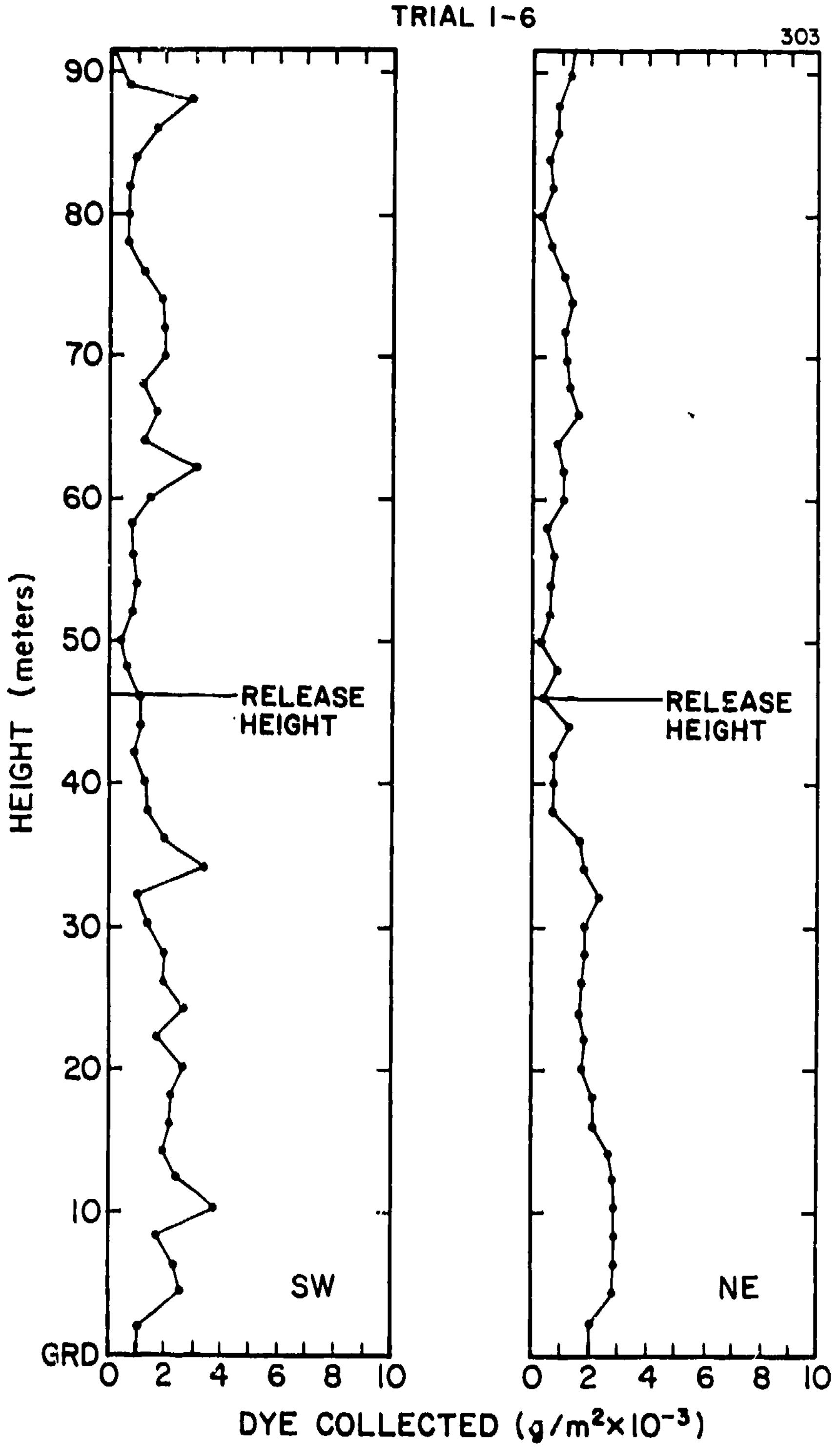


Figure 4-34. Vertical Profile of Dye Collected in Trial 1-6 from Ground Level to 90 Meters

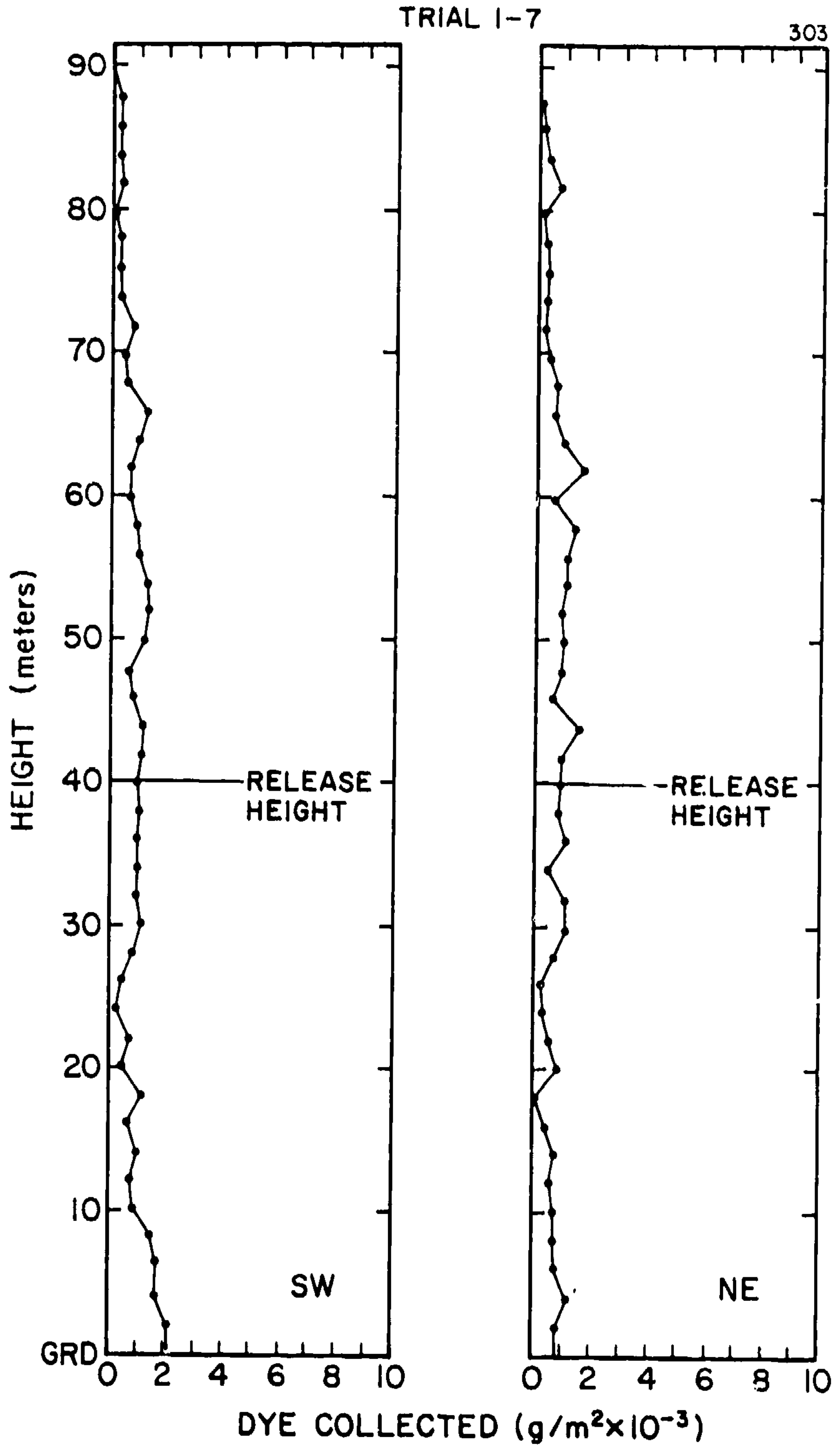


Figure 4-35. Vertical Profile of Dye Collected in Trial 1-7 from Ground Level to 90 Meters

Table 4-4. Vertical Sampling Data and Efficiency for Trial 1-2 (SW)

Sampling Data

Tower Station (m)	Dye Concentration (γ/mℓ)	Dye Concentration (g/m²)	Area Assigned (m²)	Amount Dye (g x 10^{-3})	Grid Position	Dye Concentration (γ/mℓ)	Dye Concentration (g/m²)	Area Assigned (m²)	Amount Dye (g x 10^{-3})
SW 02	0.29	1.92	3	5.76	SW 50	0.11	0.73	2	1.46
04	0.19	1.26	2	2.52	52	0.10	0.66	2	1.32
06	0.23	1.52	2	3.04	54	0.17	1.12	2	2.24
08	0.21	1.39	2	2.78	56[b]	0.21	1.39	2	2.78
10	0.32	2.11	2	4.11	58	0.25	1.65	2	3.30
12	0.20	1.32	2	2.64	60	0.26	1.72	2	3.44
14	0.23	1.52	2	3.04	62	0.20	1.32	2	2.64
16	0.23	1.52	2	3.04	64	0.23	1.52	2	3.04
18	0.20	1.32	2	2.64	66	0.18	1.19	2	2.38
20	0.22[a]	1.45	2	2.90	68	0.25	1.65	2	3.30
22	0.24	1.59	2	3.18	70	0.16	1.06	2	2.12
24	0.21	1.39	2	2.78	72	0.19	1.26	2	2.52
26	0.27	1.78	2	3.56	74	0.20	1.32	2	2.64
28	0.22	1.45	2	2.90	76	0.14	0.92	2	1.84
30	0.21	1.39	2	2.78	78	0.11	0.73	2	1.46
32	0.15	0.99	2	1.98	80	0.13[a]	0.86	2	1.72
34	0.19	1.26	2	2.52	82	0.15	0.99	2	1.98
36	0.18	1.19	2	2.38	84	0.17[a]	1.12	2	2.24
38	0.23	1.52	2	3.04	86	0.17[a]	1.12	2	2.24
40	0.21	1.39	2	2.78	88	0.19	1.26	2	2.52
42	0.21	1.39	2	2.78	90	0.15	0.99	2	1.98
44	0.16	1.06	2	2.12	92	0.20	1.32	>2	>2.64
46	0.19	1.26	2	2.52					
48	0.19	1.26	2	2.52				Total Dye Recovered	122.11

Simulant Dissemination and Meteorology

Flow Rate	14.51 ℓ/sec (230[c] gal/min)	Wind Direction	130° true
Dye Concentration	5.0 g/ℓ	Wind Speed	1.1 m/sec
Aircraft Ground Speed	216 knots (250 mph)	Source Amount	6.49X10^{-1} g/m
Release Height	55 m (180 ft)		
Flight Line	225° True	Efficiency	18.8 percent

(Continued)

[a] Value estimated.

[b] Release Height.

[c] Programmed flow rate; improper valving resulted in a lesser flow rate.

Table 4-4. Vertical Sampling Data and Efficiency for Trial 1-2 (NE) (Concluded)

Sampling Data

Tower Station (m)	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})	Grid Position	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})
NE 02	0.21	1.39	3	4.17	NE 50	0.18	1.19	2	2.38
04	0.22	1.45	2	2.90	52	0.21	1.39	2	2.78
06	0.24	1.59	2	3.18	54[b]	0.27	1.78	2	3.56
08	0.25	1.65	2	3.30	56	0.34	2.25	2	4.50
10	0.27	1.78	2	3.56	58	0.25	1.65	2	3.30
12	0.26	1.72	2	3.44	60	0.17	1.12	2	2.24
14	0.25	1.65	2	3.30	62	0.19	1.26	2	2.52
16	0.29	1.92	2	3.84	64	0.11	0.73	2	1.46
18	0.27	1.78	2	3.56	66	0.17	1.12	2	2.24
20	0.34	2.25	2	4.50	68	0.16	1.06	2	2.12
22	0.17	1.12	2	2.24	70	0.14	0.92	2	1.84
24	0.20	1.32	2	2.64	72	0.14	0.92	2	1.84
26	0.24	1.59	2	3.18	74	0.12	0.79	2	1.58
28	0.19	1.26	2	2.52	76	0.16	1.06	2	2.12
30	0.14	0.92	2	1.84	78	0.11	0.73	2	1.46
32	0.18	1.19	2	2.38	80	0.08[a]	0.53	2	1.06
34	0.21	1.39	2	2.78	82	0.06	0.40	2	0.80
36	0.25	1.65	2	3.30	84	0.08	0.53	2	1.06
38	0.26	1.72	2	3.44	86	0.14	0.92	2	1.84
40	0.18	1.19	2	2.38	88	0.14	0.92	2	1.84
42	0.19	1.26	2	2.52	90	0.09	0.60	2	1.20
44	0.18	1.19	2	2.38	92	0.16	1.06	>2	2.12
46	0.17	1.12	2	2.24					
48	0.16	1.06	2	2.12			Total Dye Recovered		117.57

Simulant Dissemination and Meteorology

Flow Rate	14.51 ℓ/sec (230[c] gal/min)	Wind Direction	130° true
Dye Concentration	5.0 g/ℓ	Wind Speed	1.1 m/sec
Aircraft Ground Speed	216 knots (250 mph)	Source Amount	6.49×10^{-1} g/m
Release Height	55 m (180 ft)		
Flight Line	225° True	Efficiency	18.2 percent

[a] Value estimated.

[b] Release Height.

[c] Programmed flow rate; improper valving resulted in a lesser flow rate.

Table 4-5. Vertical Sampling Data and Efficiency for Trial 1-3 (SW)

Sampling Data

Tower Station (m)	Dye Concentration		Area Assigned	Amount Dye	Grid Position	Dye Concentration		Area Assigned	Amount Dye
	(γ/mℓ)	(g/m²)	(m²)	(g x 10⁻³)		(γ/mℓ)	(g/m²)	(m²)	(g x 10⁻³)
SW 02	0.36	2.38	3	7.14	SW 50	0.35	2.31	2	4.62
04	0.54	3.57	2	7.14	52	0.46	3.04	2	6.08
06	0.54	3.57	2	7.14	54	0.44	2.91	2	5.82
08	0.55	3.63	2	7.26	56	0.39	2.58	2	5.16
10	0.31	2.05	2	4.10	58	0.35	2.31	2	4.62
12	0.38	2.51	2	5.02	60	0.46	3.04	2	6.08
14	0.25	1.65	2	3.30	62	0.47	3.10	2	6.20
16	0.21	1.39	2	2.78	64	0.52	3.44	2	6.88
18	0.25	1.65	2	3.30	66	0.48	3.17	2	6.34
20	0.24	1.59	2	3.18	68	0.40	2.64	2	5.28
22	0.27	1.78	2	3.56	70	0.43	2.84	2	5.68
24	0.34	2.25	2	4.50	72	0.53	3.50	2	7.00
26	0.38	2.51	2	5.02	74	0.52	3.44	2	6.88
28	0.32	2.11	2	4.22	76	0.48	3.17	2	6.34
30	0.33	2.18	2	4.36	78	0.52	3.44	2	6.88
32	0.31	2.05	2	4.10	80	0.50	3.30	2	6.60
34	0.35	2.31	2	4.62	82	0.38	2.51	2	5.02
36	0.35	2.31	2	4.62	84	0.35	2.31	2	4.62
38	0.30	1.98	2	3.96	86	0.35	2.31	2	4.62
40[a]	0.25	1.65	2	3.30	88	0.38	2.51	2	5.02
42	0.24	1.59	2	3.18	90	0.31	2.05	2	4.10
44	0.29	1.92	2	3.84	92	0.35	2.31	>2	4.62
46	0.27	1.78	2	3.56					
48	0.33	2.18	2	4.36				Total Dye Recovered	232.02

Simulant Dissemination and Meteorology

Flow Rate	14.51 ℓ/sec (230 gal/min)	Wind Direction	170° Time
Dye Concentration	4.8 g/ℓ	Wind Speed	1.2 m/sec
Aircraft Ground Speed	216 knots (250 mph)	Source Amount	6.23X10⁻¹ g/m
Release Height	46 m (151 ft)		
Flight Line	225° True	Efficiency	37.2 percent

[a]Release height.

(Continued)

Table 4-5. Vertical Sampling Data and Efficiency for Trial 1-3 (NE)(Concluded)

Sampling Data

Tower Station (m)	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})	Grid Position	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})
NE 02	0.19	1.26	3	3.78	NE 50	0.26	1.72	2	3.44
04	0.25	1.65	2	3.30	52	0.25	1.65	2	3.30
06	0.33	2.18	2	4.36	54	0.31	2.05	2	4.10
08	0.30	1.98	2	3.96	56	0.33	2.18	2	4.36
10	0.27	1.78	2	3.56	58	0.28	1.85	2	3.70
12	0.54	3.57	2	7.14	60	0.27	1.78	2	3.56
14	0.23	1.52	2	3.04	62	0.28	1.85	2	3.70
16	0.24	1.59	2	3.18	64	0.33	2.18	2	4.36
18	0.25	1.65	2	3.30	66	0.32	2.11	2	4.22
20	0.23	1.52	2	3.04	68	0.29	1.92	2	3.84
22	0.24	1.59	2	3.18	70	0.22	1.45	2	2.90
24	0.23	1.52	2	3.04	72	0.28	1.85	2	3.70
26	0.26	1.72	2	3.44	74	0.22	1.45	2	2.90
28	0.30	1.98	2	3.96	76	0.43	2.84	2	5.68
30	0.29	1.92	2	3.84	78	0.27	1.78	2	3.56
32	0.28	1.85	2	3.70	80	0.27	1.78	2	3.56
34	0.26	1.72	2	3.44	82	0.26	1.72	2	3.44
36	0.26	1.72	2	3.44	84	0.27	1.78	2	3.56
38	0.24	1.59	2	3.18	86	0.24	1.59	2	3.18
40[a]	0.26	1.72	2	3.44	88	0.23	1.52	2	3.04
42	0.24	1.59	2	3.18	90	0.29	1.92	2	3.84
44	0.28	1.85	2	3.70	92	0.21	1.39	>2	2.78
46	0.24	1.59	2	3.18					
48	0.22	1.45	2	2.90					
							Total Dye Recovered		167.00

Simulant Dissemination and Meteorology

Flow Rate	14.51 ℓ/sec (230 gal/min)	Wind Direction	170° True
Dye Concentration	4.8 g/ℓ		
Aircraft Ground Speed	216 knots (250 mph)	Wind Speed	1.2 m/sec
Release Height	46 m (151 ft)	Source Amount	6.23X10^{-1} g/m
Flight Line	225° True	Efficiency	26.8 percent

[a]Release height.

Table 4-6. Vertical Sampling Data and Efficiency for Trial 1-5 (SW)

Sampling Data

Tower Station (m)	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})	Grid Position	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})
SW 02	0.51	2.25	3	6.75	SW 50	0.18	0.79	2	1.58
04	0.82	3.61	2	7.22	52[a]	0.59	2.60	2	5.20
06	1.03	4.54	2	9.08	54	0.26	1.14	2	2.28
08	1.03	4.54	2	9.08	56	0.12	0.53	2	1.05
10	1.33	5.86	2	11.72	58	0.07	0.31	2	0.62
12	1.07	4.71	2	9.42	60	0.06	0.26	2	0.52
14	1.38	6.08	2	12.16	62	0.05	0.22	2	0.44
16	1.07	4.71	2	9.42	64	0.01	0.04	2	0.08
18	1.05	4.62	2	9.24	66	0	0	2	0
20	0.80	3.52	2	7.04	68	0	0	2	0
22	0.59	2.60	2	5.20	70	0	0	2	0
24	0.52	2.29	2	4.58	72	0	0	2	0
26	0.51	2.25	2	4.50	74	0	0	2	0
28	0.36	1.59	2	3.18	76	0	0	2	0
30	0.24	1.06	2	2.12	78	0	0	2	0
32	0.19	0.84	2	1.68	80	0	0	2	0
34	0.18	0.79	2	1.58	82	0	0	2	0
36	0.21	0.92	2	1.84	84	0	0	2	0
38	0.19	0.84	2	1.68	86	0	0	2	0
40	0.24	1.06	2	2.12	88	0	0	2	0
42	0.42	1.65	2	3.70	90	0	0	2	0
44	0.32	1.41	2	2.82	92	0	0	2	0
46	0.25	1.10	2	2.20					
48	0.21	0.92	2	1.84	Total Endosulfan Recovered				141.95×10^{-3}

Simulant Dissemination and Meteorology

Flow Rate	3.79 ℓ/sec (60 gal/min)	Wind Direction	330° True
Endosulfan Concentration	8.9 g/ℓ	Wind Speed	3.0 m/sec
Aircraft Ground Speed	216 knots (250 mph)	Source Amount	3.01×10^{-1} g/m
Release Height	52 m (171 ft)		
Flight Line	225° True	Efficiency	45.8 percent

[a]Release height.

(Continued)

Table 4-6. Vertical Sampling Data and Efficiency for Trial 1-5 (NE) (Concluded)

Sampling Data

Tower Station (m)	Dye Concentration (γ/mℓ)	Dye Concentration (g/m²)	Area Assigned (m²)	Amount Dye (g x 10^{-3})	Grid Position	Dye Concentration (γ/mℓ)	Dye Concentration (g/m²)	Area Assigned (m²)	Amount Dye (g x 10^{-3})
NE 02	0.82	3.61	3	10.83	NE 50	0.25	1.10	2	2.20
04	0.97	4.27	2	8.54	52[a]	0.25	1.10	2	2.20
06	1.22	5.37	2	10.74	54	0.20	0.88	2	1.76
08	1.36	5.99	2	11.98	56	0.12	0.53	2	1.06
10	1.44	6.34	2	12.68	58	0.07	0.31	2	0.62
12	1.44	6.34	2	12.68	60	0.08	0.35	2	0.70
14	1.46	6.43	2	12.86	62	0.06	0.26	2	0.52
16	1.35	5.95	2	11.90	64	0	0	2	0
18	1.23	5.42	2	10.84	66	0	0	2	0
20	0.92	4.05	2	8.10	68	0	0	2	0
22	0.82	3.61	2	7.22	70	0	0	2	0
24	0.64	2.82	2	5.64	72	0	0	2	0
26	0.53	2.34	2	4.68	74	0	0	2	0
28	0.37	1.63	2	3.26	76	0	0	2	0
30	0.24	1.06	2	2.12	78	0	0	2	0
32	0.22	0.97	2	1.94	80	0	0	2	0
34	0.25	1.10	2	2.20	82	0	0	2	0
36	0.26	1.14	2	2.28	84	0	0	2	0
38	0.20	0.88	2	1.76	86	0	0	2	0
40	0.31	1.37	2	2.74	88	0	0	2	0
42	0.42	1.85	2	3.70	90	0	0	2	0
44	0.42	1.85	2	3.70	92	0	0	2	0
46	0.35	1.54	2	3.08					
48	0.53	2.33	2	4.65					
					Total Endosulfan Recovered 169.19				

Simulant Dissemination and Meteorology

Flow Rate	3.79 ℓ/sec (60 gal/min)	Wind Direction	330° True
Endosulfan Concentration	8.9 g/ℓ	Wind Speed	3.0 m/sec
Aircraft Ground Speed	216 knots (250 mph)	Source Amount	3.01X10^{-1} g/m
Release Height	52 m (171 ft)		
Flight Line	225° True	Efficiency	54.5 percent

[a]Release height.

Table 4-7. Vertical Sampling Data and Efficiency for Trial 1-6 (SW)

Sampling Data

Tower Station (m)	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})	Grid Position	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})
SW 02	0.16	1.06	3	3.18	SW 50[a]	0.07	0.46	2	0.92
04	0.39	2.58	2	5.16	52	0.11	0.73	2	1.46
06	0.36	2.38	2	4.76	54	0.15	0.99	2	1.98
08	0.27	1.78	2	3.56	56	0.12	0.79	2	1.58
10	0.56	3.70	2	7.40	58	0.11	0.73	2	1.46
12	0.37	2.44	2	4.88	60	0.22	1.45	2	2.90
14	0.28	1.85	2	3.70	62	0.47	3.10	2	6.20
16	0.32	2.11	2	4.22	64	0.18	1.19	2	2.38
18	0.33	2.18	2	4.36	66	0.24	1.59	2	3.18
20	0.39	2.58	2	5.16	68	0.18	1.19	2	2.38
22	0.25	1.65	2	3.30	70	0.28	1.85	2	3.70
24	0.39	2.58	2	5.16	72	0.30	1.98	2	3.96
26	0.29	1.92	2	3.84	74	0.28	1.85	2	3.70
28	0.29	1.92	2	3.84	76	0.18	1.19	2	2.38
30	0.20	1.32	2	2.64	78	0.10	0.66	2	1.32
32	0.15	0.99	2	1.98	80	0.09	0.60	2	1.20
34	0.51	3.37	2	6.74	82	0.10	0.66	2	1.32
36	0.30	1.98	2	3.96	84	0.13	0.86	2	1.72
38	0.21	1.39	2	2.78	86	0.24	1.59	2	3.18
40	0.19	1.26	2	2.52	88	0.44	2.91	2	5.82
42	0.13	0.86	2	1.72	90	0.09	0.60	2	1.20
44	0.16	1.06	2	2.12	92	0.01	0.07	2	0.14
46	0.16	1.06	2	2.12					
48	0.09	0.60	2	1.20			Total Dye Recovered		144.38

Simulant Dissemination and Meteorology

Flow Rate	3.79 ℓ/sec (60 gal/min)	Wind Direction	300° True
Dye Concentration	4.3 g/ℓ	Wind Speed	1.0 m/sec
Aircraft Ground Speed	216 knots (250 mph)	Source Amount	1.46×10^{-1} g/m
Release Height	46 m (151 ft)		
Flight Line	225° True	Efficiency	95.7 percent

(Continued)

[a]Release height.

Table 4-7. Vertical Sampling Data and Efficiency for Trial 1-6 (NE) (Concluded)

Sampling Data

Tower Station (m)	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})	Grid Position	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})
NE 02	0.32	2.11	3	6.33	NE 50[a]	0.05	0.33	2	0.66
04	0.45	2.97	2	5.94	52	0.10	0.66	2	1.32
06	0.45	2.97	2	5.94	54	0.10	0.66	2	1.32
08	0.45	2.97	2	5.94	56	0.11	0.73	2	1.46
10	0.44	2.91	2	5.82	58	0.08	0.53	2	1.06
12	0.43	2.84	2	5.68	60	0.18	1.19	2	2.38
14	0.41	2.71	2	5.42	62	0.17	1.12	2	2.24
16	0.31	2.05	2	4.10	64	0.14	0.92	2	1.84
18	0.32	2.11	2	4.22	66	0.24	1.59	2	3.18
20	0.26	1.72	2	3.44	68	0.20	1.32	2	2.64
22	0.28	1.85	2	3.70	70	0.19	1.26	2	2.52
24	0.26	1.72	2	3.44	72	0.18	1.19	2	2.38
26	0.27	1.78	2	3.56	74	0.22	1.45	2	2.90
28	0.28	1.85	2	3.70	76	0.18	1.19	2	2.38
30	0.28	1.85	2	3.70	78	0.10	0.66	2	1.32
32	0.36	2.38	2	4.76	80	0.05	0.33	2	0.66
34	0.26	1.72	2	3.44	82	0.11	0.73	2	1.46
36	0.26	1.72	2	3.44	84	0.09	0.60	2	1.20
38	0.12	0.79	2	1.58	86	0.15	0.99	2	1.98
40	0.12	0.79	2	1.58	88	0.14	0.92	2	1.84
42	0.12	0.79	2	1.58	90	0.20	1.32	2	2.64
44	0.20	1.32	2	2.64	92	0.24	1.59	>2	>3.13
46	0.07	0.46	2	0.92					
48	0.14	0.92	2	1.84		Total Dye Recovered			135.27

Simulant Dissemination and Meteorology

Flow Rate	3.79 ℓ/sec (60 gal/min)	Wind Direction	300° True
Dye Concentration	4.3 g/ℓ	Wind Speed	1.0 m/sec
Aircraft Ground Speed	216 knots (250 mph)	Source Amount	1.46X10^{-1} g/m
Release Height	46 m (151 ft)		
Flight Line	225° True	Efficiency	89.7 percent

[a]Release height.

Table 4-8. Vertical Sampling Data and Efficiency for Trial 1-7 (SW)

Sampling Data

Tower Station (m)	Dye Concentration		Area Assigned (m^2)	Amount Dye (g x 10^{-3})	Grid Position	Dye Concentration		Area Assigned (m^2)	Amount Dye (g x 10^{-3})
	(γ/mℓ)	(g/m^2)				(γ/mℓ)	(g/m^2)		
SW 02	0.31	2.05	3	6.15	SW 50	0.17	1.12	2	2.24
04	0.25	1.65	2	3.30	52[a]	0.19	1.26	2	2.52
06	0.24	1.59	2	3.18	54	0.19	1.26	2	2.52
08	0.22	1.45	2	2.90	56	0.14	0.92	2	1.84
10	0.14	0.92	2	1.84	58	0.13	0.86	2	1.72
12	0.10	0.66	2	1.32	60	0.10	0.66	2	1.32
14	0.14	0.92	2	1.84	62	0.10	0.66	2	1.32
16	0.08	0.53	2	1.06	64	0.14	0.92	2	1.84
18	0.16	1.06	2	2.12	66	0.18	1.19	2	2.38
20	0.07	0.46	2	0.92	68	0.08	0.53	2	1.06
22	0.10	0.66	2	1.32	70	0.07	0.46	2	0.92
24	0.04	0.26	2	0.52	72	0.10	0.66	2	1.32
26	0.07	0.46	2	0.92	74	0.04	0.26	2	0.52
28	0.12	0.79	2	1.58	76	0.03	0.20	2	0.40
30	0.17	1.12	2	2.24	78	0.03	0.20	2	0.40
32	0.13	0.86	2	1.72	80	0.01	0.07	2	0.14
34	0.13	0.86	2	1.72	82	0.04	0.26	2	0.52
36	0.13	0.86	2	1.72	84	0.03	0.20	2	0.40
38	0.15	0.99	2	1.98	86	0.02	0.13	2	0.26
40	0.14	0.92	2	1.84	88	0.03	0.20	2	0.40
42	0.16	1.06	2	2.12	90	0	0	0	0
44	0.17	1.12	2	2.24	92	0	0	0	0
46	0.12	0.79	2	1.58					
48	0.08	0.53	2	1.06					

Total Dye Recovered 71.23×10^{-3}

Simulant Dissemination and Meteorology

Flow Rate	1.58 ℓ/sec (25 gal/min)	Wind Direction	305° True
Dye Concentration	4.4 g/ℓ	Wind Speed	1.8 m/sec
Aircraft Ground Speed	216 knots (250 mph)	Source Amount	6.21×10^{-2} g/m
Release Height	40 m (131 ft)		
Flight Line	225° True	Efficiency	112.4 percent

(Continued)

[a]Release height.

Table 4-8. Vertical Sampling Data and Efficiency for Trial 1-7 (NE) (Concluded)

Sampling Data

Tower Station (m)	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})	Grid Position	Dye Concentration (γ/mℓ)	Dye Concentration (g/m^2)	Area Assigned (m^2)	Amount Dye (g x 10^{-3})
NE 02	0.14	0.92	3	2.76	NE 50[a]	0.15	0.99	2	1.98
04	0.18	1.19	2	2.38	52	0.13	0.86	2	1.72
06	0.12	0.79	2	1.58	54	0.16	1.06	2	2.12
08	0.10	0.66	2	1.32	56	0.16	1.06	2	2.12
10	0.09	0.60	2	1.20	58	0.22	1.45	2	2.90
12	0.08	0.53	2	1.06	60	0.09	0.60	2	1.20
14	0.10	0.66	2	1.32	62	0.25	1.65	2	3.30
16	0.07	0.46	2	0.92	64	0.14	0.92	2	1.84
18	0.02	0.13	2	0.26	66	0.08	0.53	2	1.06
20	0.13	0.86	2	1.72	68	0.10	0.66	2	1.32
22	0.08	0.53	2	1.06	70	0.07	0.46	2	0.92
24	0.05	0.33	2	0.66	72	0.03	0.20	2	0.40
26	0.05	0.33	2	0.66	74	0.04	0.26	2	0.52
28	0.10	0.66	2	1.32	76	0.05	0.33	2	0.66
30	0.18	1.19	2	2.38	78	0.04	0.26	2	0.52
32	0.16	1.06	2	2.12	80	0.02	0.13	2	0.26
34	0.06	0.40	2	0.80	82	0.11	0.73	2	1.46
36	0.16	1.06	2	2.12	84	0.06	0.40	2	0.80
38	0.11	0.73	2	1.46	86	0.03	0.20	2	0.40
40	0.13	0.86	2	1.72	88	0	0	2	0
42	0.14	0.92	2	1.84	90	0	0	2	0
44	0.23	1.52	2	3.04	92	0	0	2	0
46	0.09	0.60	2	1.20					
48	0.13	0.86	2	1.72				Total Dye Recovered	62.12

Simulant Dissemination and Meteorology

Flow Rate	1.58 ℓ/sec (25 gal/min)	Wind Direction	305° True
Dye Concentration	4.4 g/ℓ	Wind Speed	1.8 m/sec
Aircraft Ground Speed	216 knots (250 mph)	Source Amount	6.21X10^{-2} g/m
Release Height	40 m (131 ft)		
Flight Line	225° True	Efficiency	98.0 percent

[a]Release Height.

Trial 1-1. Spray system malfunctions caused fluctuations in flow rate and spillage from petcock. Therefore, tower samplers not assayed.

Trial 1-1R. Spray system not primed. Therefore, tower samplers not assayed

Trial 1-2. Samplers assayed. Spray system set to release 230 gallons per minute, but observers suspect something less. A problem existed with the spray recirculating system. Very light winds approximately 45° from normal to flight line. The aerosol cloud was not contained on the 92-meter sampling array and certainly accounts for a loss of some material. The efficiency measured in this trial is low and must be considered of limited value in characterizing the system.

Trial 1-3. Samplers assayed. Spray system set to release 230 gallons per minute. Light winds and an unsatisfactory wind direction for characterizing efficiency of the system existed at time of release. This trial has been classed as an inwind trial. Cloud height at tower was greater than 92-meters (highest sampler on the tower). The efficiency estimates cannot be used to characterize the spray system.

Trial 1-4. Samplers not assayed. Spray system set to release 25 gallons per minute. The wind at time of release was nearly calm.

Trial 1-5. Samplers assayed. Trial considered a good trial. This trial was used to characterize dissemination efficiency.

Trial 1-6. Samplers assayed. Trial considered good for efficiency estimate of system. This trial had Dupont oil red dye mixed with Duphar. The amount of oil red dye was analyzed. Some dye was detected at 92-meters; however, there is good indication from the concentration profile and the calculated recovery that very little of the cloud was above this height.

Trial 1-7. Samplers assayed. Trial considered good for efficiency estimates of system. This trial had Dupont oil red dye mixed with Duphar. Samplers were analyzed for oil red dye content. Cloud was contained within the 92-meter sampling array. While efficiency exceeded 100 percent, this is not unusual from a single-tower array when a mean of 100 is expected from a number of efficiency calculations.

4.4 CALCULATION OF DROPLET SIZE

Volume median diameter (vmd) and number mean diameter (nmd) of the spray droplets as expressed in micrometers are presented in Table 4.9.

Table 4.9. VMD and NMD for each trial

TRIAL NO.	SPRAY MATERIAL	VMD (μm)	NMD (μm)
1-4	Fuel oil	54	32
1-7	Duphar	63	47
2-3	Fuel oil	50	32
1-5	Fuel oil	55	34
1-6	Duphar	68	44
2-2R	Fuel oil	57	36
1-1	Fuel oil	71	35
1-2	Fuel oil	58	32
1-3	Fuel oil	60	35
2-1	Fuel oil	52	31

CHAPTER 5. DEPOSITION MODEL

5.1 INTRODUCTION

Aerial spray systems previously tested have typically produced large drops. Also, satisfactory techniques for collecting and sizing small drops less than 50 micrometers in diameter have generally been lacking. For these reasons, deposition measurements for drops less than 50 micrometers in diameter have not been available. The deposition measurements made during the U. N. spray trials thus provide the first opportunity to validate the generalized deposition models previously developed for Dugway Proving Ground for drop sizes below 100 micrometers.

The DPG deposition models described by Cramer et al., (1972) apply strictly to drops with appreciable settling velocities assuming that all drops deposited are retained and not reflected. For drops less than 100 micrometers in diameter, this assumption probably does not hold. Since 1972, development and refinement of the DPG deposition models have continued, and provision has been made for partial reflection of small drops at the ground. The U. N. spray trial, where the smaller drops were expected to be partially reflected at the ground, thus provided an opportunity for validating the partial reflection features of the DPG deposition model.

In three trials, the flight path was approximately parallel to the wind direction. In the remaining seven trials, the flight path was approximately perpendicular to the mean wind direction. The altitude of the aircraft during the trials was approximately 50 meters above the ground. Two types of spray carrier were used. Duphar, a trade-name solvent of low volatility, was used in Trials 1-6 and 1-7. In the remaining eight trials, No. 2 Fuel Oil was used. Dupont Oil Red Dye was added to both types of spray carrier as a tracer. Figure 5-1 shows cumulative mass determined by this procedure for the two Duphar trials and for seven trials in which fuel oil was the carrier. As shown in Figure 5-1, the mass median diameter obtained for the Duphar is approximately 66 micrometers, while the mass median diameter for the No. 2 fuel oil is approximately 55 micrometers. Less than 1 percent of the total mass of each spray carrier is contained in drops with diameters larger than 150 micrometers.

5.2 MEASUREMENTS, OBSERVED DEPOSTION, AND AIRCRAFT EFFECTS ON SPRAY CLOUD

5.2.1 Deposition and Meteorologal Measurements

The spray trials were conducted on three grids of different forms. Trials 1-1, 1-3, 1-5, 1-6 and 1-7 were conducted on grid A, Figure 5-2. The open circles in Figure 5-2 indicate the positions of Printflex-card samplers. The flight path of the aircraft was approximately perpendicular

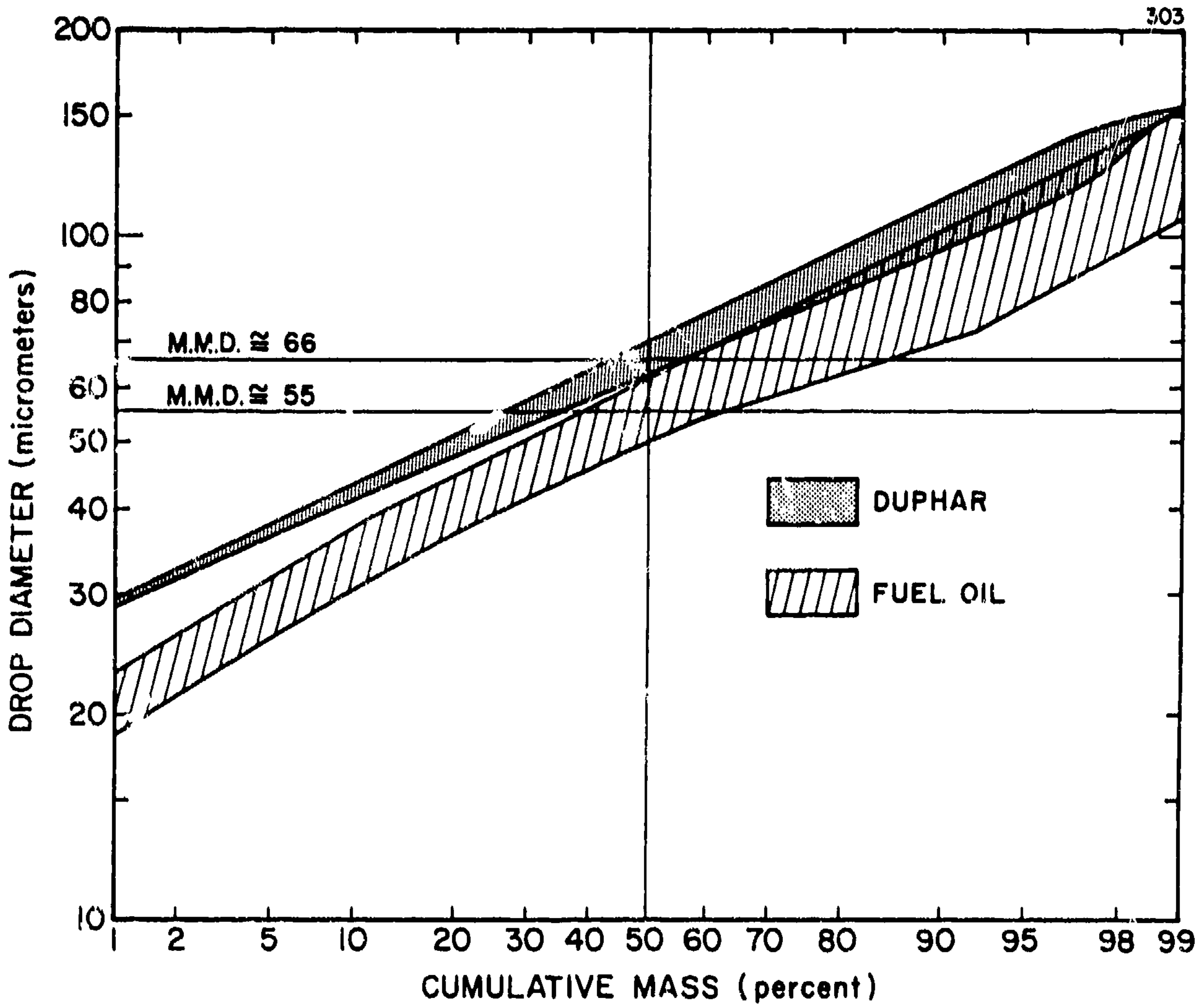


FIGURE 5-1. Envelopes of measured drop-size distributions for two Duphar trials and seven fuel oil trials.

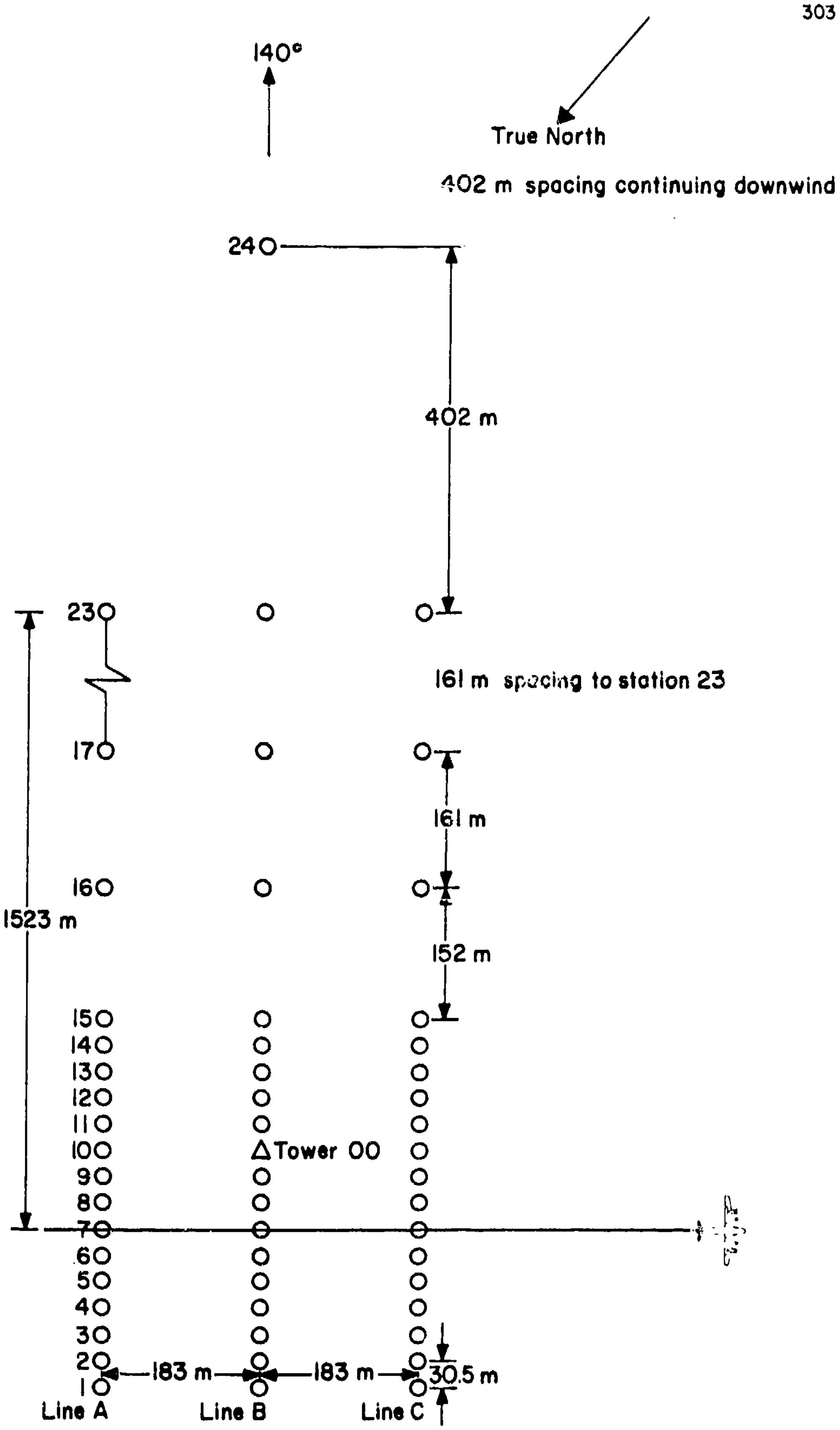


FIGURE 5-2. Grid A.

to sampling lines A, B and C, parallel to the sampling positions along row 7. The sampling stations on rows 1 through 6 measured deposition upwind of the flight path. Sampling lines A, B and C extended 1,523 meters from the flight line. Sampling line C continued beyond this point, with deposition samplers at intervals of 402 meters, to about 16 kilometers from the flight line. Vertical spray samples were collected on the 98-meter tower (00, Figure 5-3) 90 meters from the flight line. Cylindrical (pipe-cleaner) samplers were positioned at 2-meter intervals on both the northeast and southwest corners of the tower between heights of 2 and 92 meters. Dye leached from these samplers were used to determine the dissemination efficiency of the spray system. Trials 1-2 and 1-4 were conducted on grid B, a grid nearly identical to grid A, but reversed 180 degrees so that it could be used when the winds were from the south. Because of large shifts in wind direction (see Section 5.1), these trials were not used for model validation, so grid B is not presented here.

Trials 2-1, 2-2R and 2-3 were conducted on grid C (Figure 5-3). Printflex-card deposition samplers were placed as shown in the figure. Sampling lines D, E and F were separated by 1,097 meters, the samplers 46 meters apart along each line. As shown in Figure 5-3, the flight path for Trials 2-2R and 2-3 crossed lines D, E and F near the center of the grid. No measurements of dissemination efficiency were made for trials conducted on grid C, because the grid had no tall tower.

Meteorological measurements were made on Towers 00 (Figure 5-2) and 12 (Figure 5-3) for all trials. Tower 12 is about 9.7 kilometers (6 miles) northwest of Tower 00. Standard deviations of the wind azimuth and elevation angles were obtained from bidirectional vane measurements made at heights of 2, 16, 32, 64, 80 and 96 meters on Tower 00. Wind directions and wind speeds were also measured at these heights. Temperature measurements were made on Tower 00 at heights of 0.5, 2, 16, 32, 64 and 96 meters. Similar measurements of wind speed, wind direction, standard deviations of the wind azimuth and elevation angles and temperature were made at heights of 2, 16 and 32 meters on Tower 12. PIBAL measurements of wind speed and direction in the first few thousand feet above the surface were also made in the vicinity of the flight line for all trials.

5.2.2 Treatment of the Deposition Measurements

The deposition observed by visual (microscopic) counting and sizing of drop stains on Printflex cards was tabulated in milligrams per square meter for each sampling position for each trial. On grids A and C, the deposition data for each set of three crosswind sampling positions approximately equidistant from the flight path were averaged to obtain a single value for the observed deposition at each of the distances away from the flight line indicated by the positions of the samplers on lines B and E.

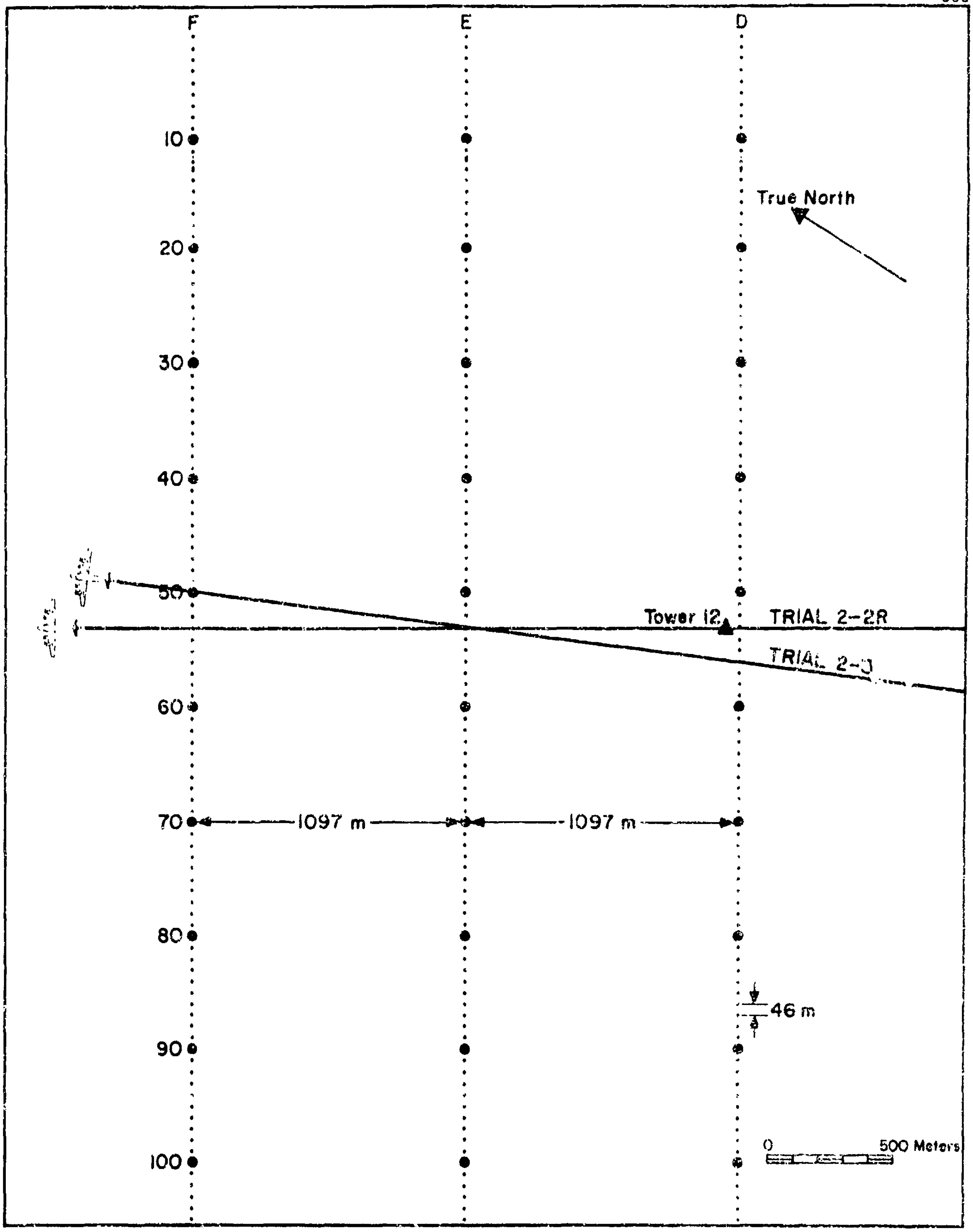


FIGURE 5-3. Grid C.

In the trials conducted on grid C, when the direction of the flight path was approximately into the wind, deposition occurred on both sides of the flight path. Profiles of average deposition versus distance from the flight path were constructed, following the procedure outlined above, for both sides of the flight path.

5.2.3 Effect of Trailing Vortices on the Spray Cloud

Photographs of the spray cloud show, as might be expected, that the droplets emitted from the nozzles were quickly swept into the four propeller-slipstream vortices and the two wing-tip vortices to form six cylindrical vortex tubes that extend aft from the trailing edge of the wing. Behind the aircraft, the entire vortex system sinks toward the ground with an average downward velocity of about 0.7 meter per second. The time required for the vortex circulations to decay depends on many factors, including the aircraft weight, air speed, and altitude, as well as turbulence. Figure 5-4 shows the descent and spreading of the wing-tip vortices in calm air and in a light crosswind. As pointed out by Jones (1970, p. 22), the descent of the entire vortex system containing the spray drops stops when the centers of the wing-tip vortices are about one-half wingspan (15 meters) above the ground. In calm air, each wing-tip vortex then moves laterally outward and away from the flight line with a speed approximately equal to the descent rate. In a light crosswind approximately equal to the descent rate, the downwind vortex moves outward with a speed equal to the sum of the wind speed and the descent rate, while the upwind vortex tends to remain stationary. The times shown in Figure 5-4 are rough estimates of the time required for the vortex system containing the spray to sink to the ground and for the spray cloud to approach an approximate equilibrium with existing conditions. The spray cloud, 1 to 2 minutes after the passage of the aircraft, is thus in the form of a partially flattened cylindrical tube touching the ground and extending back along the flight path toward the point where the spray release began. The tube diameter, approximately normal to the projection of the aircraft flight path on the ground, is about two to three wing spans (56 to 84 meters). The center of the spray tube is about 15 meters above the ground, and the top of the tube is about 75 meters above the ground.

During the first few minutes after the release of the spray, wake vortices thus principally control the growth of the spray cloud and, except for the possible lateral translation of the vortex system by a crosswind, the position of the cloud in space as well as the amount of spray deposited on the ground directly below the flight path. After the first few minutes, when the vortex circulations within the spray cloud have decayed and approximate equilibrium has been reached, meteorological factors in conjunction with settling control the transport, diffusion and deposition of spray.

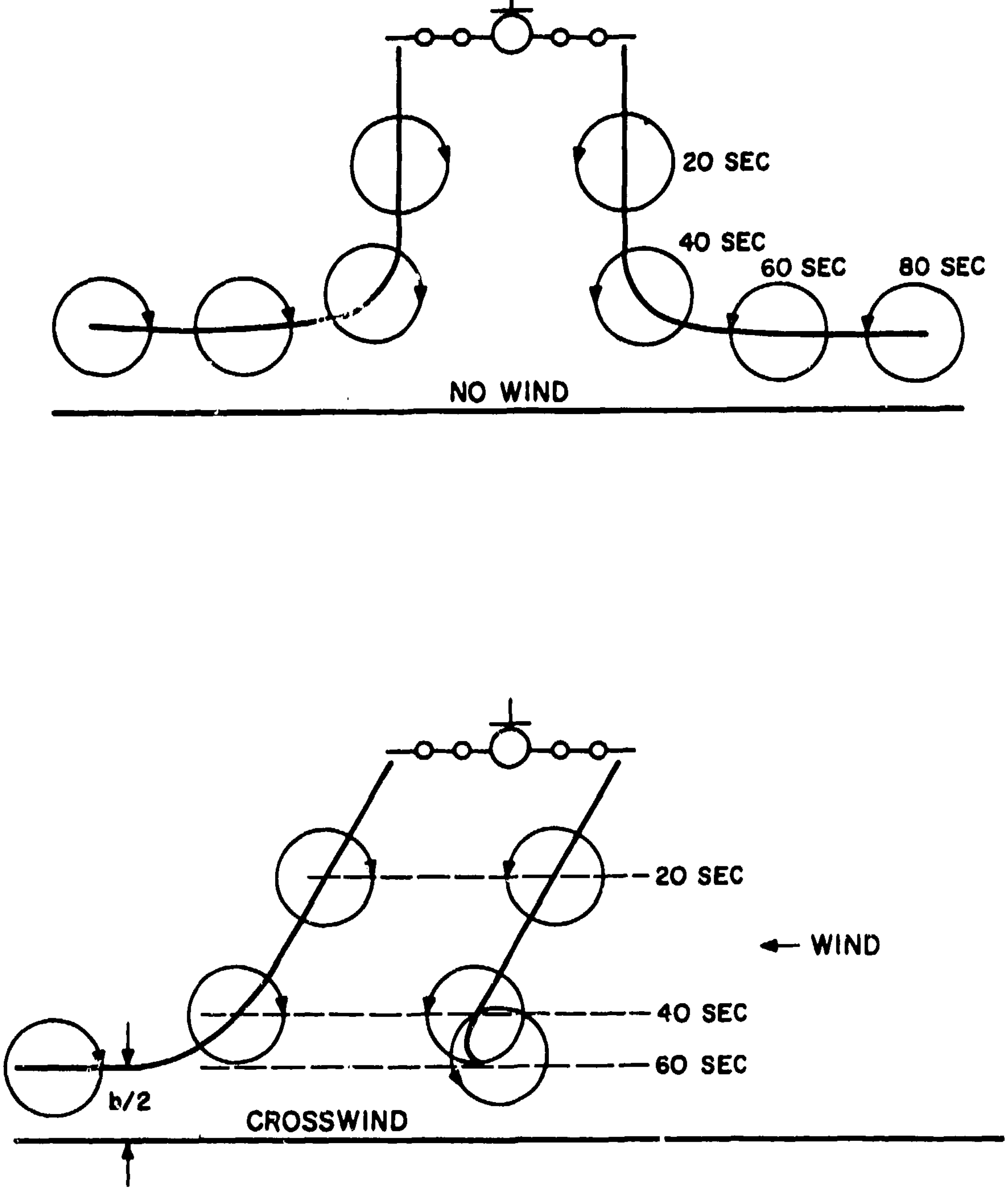


FIGURE 5-4. Descent and spreading of wing-tip vortices from the aircraft in still air and in a light crosswind. The symbol b stands for aircraft wingspan.

In the deposition model described below, the source parameters correspond to the properties of the spray cloud when the cloud has reached approximate equilibrium (see Section 5.4.2). For the crosswind trials, it was assumed that this approximate equilibrium had been reached when the cloud passed through Tower 00, about 100 meters from the flight line. The spray measurements made on Tower 00 were used to estimate the effective height and vertical dimension of the source. The lateral source dimension σ_{yo} was assumed to be 20 meters in all trials. This corresponds to a cloud 84 meters (3 wing spans) in diameter (Figure 5-4). This lateral source dimension σ_{yo} is important only for the trials conducted on grid C when the flight path was into the wind.

5.3 DEPOSITION MODEL

The model described below for calculating the deposition from a nearly instantaneous elevated line source is similar to the DPG generalized deposition models described by Cramer, et al., (1972). In the deposition model, the axis of the spray cloud is assumed as intersecting the ground at a downwind distance proportional to the effective height of release, the settling velocity V_s of the droplets, and the mean transport speed of the cloud $\bar{u}$. The inclination of the cloud axis from the horizontal for any given drop-size category is equal to $\tan^{-1}(V_s|\bar{u})$. The deposition model provides for partial reflection of drops at the ground. Drops dispersed upward by turbulence are totally reflected downward at the top of the surface mixing layer, but the fraction of drops γ reflected at the ground is a variable input parameter for each settling-velocity category.

For the trials in which the flight paths were approximately parallel to the mean wind direction rather than perpendicular to it, the line source was simulated by placing a discrete number of point sources along the portion of the line source "seen" by a sampler downwind from the line source as shown in Figure 5-5, the receptor is assumed to see the upwind portion of the line source within a sector defined by 2.15 standard deviations of the wind azimuth σ_A on either side of the mean wind direction. The number of point sources required to simulate the line source for any given receptor increases as the acute angle between the wind direction and the line source becomes smaller. In the computer program, enough point sources were used to obtain a stable numerical solution for the deposition at the receptor.

The total deposition at a sampling point is obtained by summing the calculated deposition over all settling-velocity categories used to represent the drop-size distribution and over all point sources used to simulate the line source. Thus, the elevated point-source model for deposition caused by settling is given by the following expression where, for convenience, 0^0 (zero to the zero power) is defined as 1:

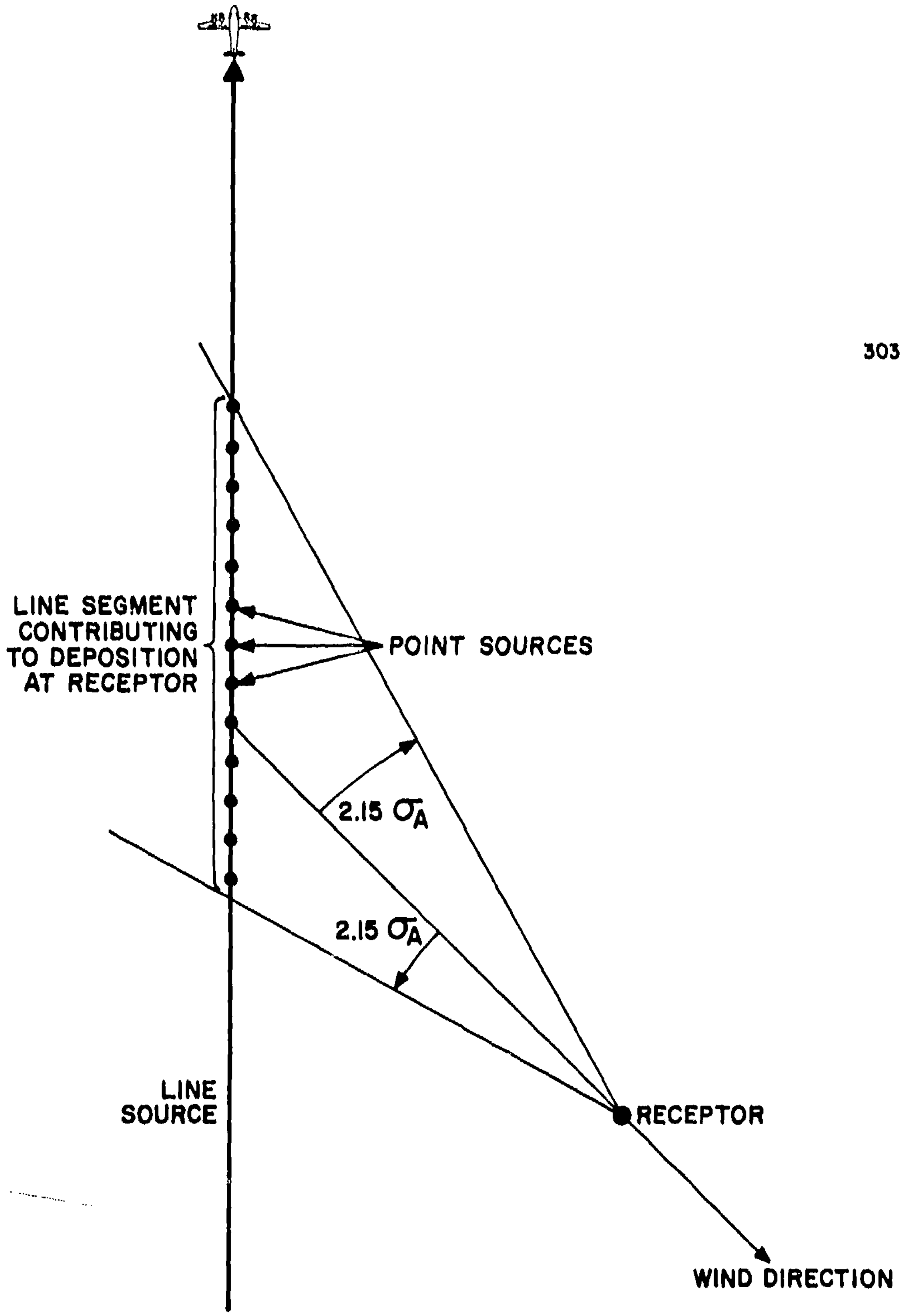


FIGURE 5-5. The use of point sources to simulate the line-source segment contributing to the deposition at a receptor point downwind from the line source.

$$\mathrm{Dep} = \frac{f_i\,Q\,K\,(1-\gamma_i)}{2\pi\,\sigma_y\,\sigma_z\,(x+x_z)} \left\{ \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \right\}$$

$$\left\{ \left[H + V_{si}x_z/\bar{u}\right] \left[\exp\left(-\frac{1}{2}\left(\frac{H - V_{si}x/\bar{u}}{\sigma_z}\right)^2\right)\right] \right. \tag{5-1}$$

$$+ \sum_{a=1}^{\infty} \gamma_i^{a-1} \left\{ \left[2a\,H_m - H - V_{si}x_z/\bar{u}\right] \left[\exp\left(-\frac{1}{2}\left(\frac{2a\,H_m - H + V_{si}x/\bar{u}}{\sigma_z}\right)^2\right)\right] \right.$$

$$\left. \left. + \gamma_i \left[2a\,H_m + H + V_{si}x/\bar{u}\right] \left[\exp\left(-\frac{1}{2}\left(\frac{2a\,H_m + H - V_{si}x/\bar{u}}{\sigma_z}\right)^2\right)\right] \right\} \right\}$$

where:

f_i = fraction of the total source comprising droplets in the i^{th} size category

Q = source strength assigned to each point source

K = scaling coefficient used to convert input parameters to dimensionally consistent units

γ_i = fraction of the material in the i^{th} droplet-size category reflected at the surface (1 for complete reflection and 0 for no reflection)

H = release height

H_m = depth of the surface mixing layer

V_{si} = settling velocity for the i^{th} droplet-size category

$\bar{u}$ = mean transport wind speed

x_z = vertical virtual distance

$$
= \begin{cases} \dfrac{\sigma_{zR}}{\sigma'_E} - x_{Rz} & ; \ \sigma_{zR} \le \sigma'_E \, x_{rz} \\[2ex] \beta \, x_{rz} \left(\dfrac{\sigma_{zR}}{\sigma'_E \, x_{rz}} \right)^{1/\beta} - x_{Rz} + x_{rz} \, (1-\beta) & ; \ \sigma_{zR} > \sigma'_E \, x_{rz} \end{cases} \tag{5-2}
$$

σ_{zR} = standard deviation of the vertical concentration distribution at x_{Rz} downwind from the source

σ'_E = standard deviation of the wind-elevation angle in radians at height H

β = vertical diffusion coefficient

x_{rz} = distance over which rectilinear vertical cloud expansion occurs downwind from an ideal point source

σ_z = the standard deviation of the vertical concentration distribution

$$
= \sigma'_E \, x_{rz} \left[\frac{x + x_z - x_{rz} \quad -\beta)}{\beta \, x_{rz}} \right]^{\beta} \tag{5-3}
$$

σ_y = the standard deviation of the crosswind concentration distribution

$$
= \left[\left(\sigma'_A(\tau) \, x_{ry} \left(\frac{x + x_y - x_{ry} \, (1-\alpha)}{\alpha \, x_{ry}} \right)^{\alpha} \right)^2 + \left(\frac{\Delta \theta' x}{4.3} \right)^2 \right]^{1/2} \tag{5-4}
$$

$\sigma'_A[r]$ = standard deviation of the wind azimuth in radians at height H measured over the source emission time τ

$\sigma'_A[r]$ =

$$
\sigma'_A\{\tau\} = \sigma'_A\{\tau_o\} \left(\frac{\tau}{\tau_o} \right)^{1/5} \quad ; \quad 1 \le \tau_o \le 600 \text{ seconds} \tag{5-5}
$$

$\sigma'_A[\tau_o]$ = standard deviation of the azimuth wind angle in radians in the surface mixing layer measured over the reference time τ_o

x_{ry} = distance over which rectilinear crosswind cloud expansion occurs downwind from the virtual point source

α = crosswind diffusion coefficient

x_y = crosswind virtual distance

$$= \begin{cases} \dfrac{\sigma_{yR}}{\sigma'_A\{\tau\}} - x_{Ry} & ; \ \sigma_{yR} \le \sigma'_A\{\tau\}\, x_{ry} \\ \alpha x_{ry} \left(\dfrac{\sigma_{yR}}{\sigma'_A(\tau)\, x_{ry}}\right)^{1/\alpha} - x_{Ry} + x_{ry}(1-\alpha) & ; \ \sigma_{yR} > \sigma'_A\{\tau\}\, x_{ry} \end{cases} \tag{5-6}$$

σ_{yR} = standard deviation of the crosswind concentration distribution at a distance x_{Ry} downwind from the source

$\Delta\theta'$ = wind azimuth shear in radians with the layer containing the cloud

$$= \frac{\Delta\theta'}{\Delta z}\left(z_2 - z_1\right) \tag{5-7}$$

$\frac{\Delta\theta'}{\Delta z}$ = rate of change in wind direction (radians) with height in the surface mixing layer

z_2 = effective upper bound of the cloud

$$= \begin{cases} H + 2.15\,\sigma_z & ; \ z_2 \le H_m \\ H_m & ; \ z_2 > H_m \end{cases} \tag{5-8}$$

z_1 = effective lower bound of the cloud

$$= \begin{Bmatrix} H - 2.15\,\sigma_z & ; & z_1 \geq 0 \\ 0 & ; & z_1 < 0 \end{Bmatrix} \qquad (5\text{-}9)$$

The source strength Q for each point source along the portion of the line affecting deposition at a receptor is defined by the expression

$$Q = \frac{Q_T \, \mathrm{Eff} \, L_s}{L \, N} \qquad (5\text{-}10)$$

where

Q_T = total source strength

Eff = dissemination efficiency of the spray system

L_s = portion of the line source contributing to deposition at the receptor

L = total line-source length

N = number of point sources used in simulating the line-source length L_s

The lateral source dimension of each point source using the line-source-simulation technique is given by the expression:

$$\sigma_{yR} = \begin{Bmatrix} \sigma_{yL} \cos\Phi & ; & \sigma_{yL} \cos\Phi \geq \dfrac{L_s \sin\Phi}{2.15\,N} \\ \dfrac{L_s \sin\Phi}{2.15\,N} & ; & \sigma_{yL} \cos\Phi < \dfrac{L_s \sin\Phi}{2.15\,N} \end{Bmatrix} \qquad (5\text{-}11)$$

where

ϕ = the acute angle between the wind direction and the line source

σ_{yL} = the standard deviation of the lateral concentration distribution of the line source at release

5.4 METEOROLOGICAL AND SOURCE INPUTS USED IN CALCULATIONS

5.4.1 Meteorological Inputs

The meteorological inputs used in the deposition model were derived primarily from PIBAL soundings and measurements made at Towers 00 and 12. Dugway Proving Ground provided 5-minute mean wind directions and wind speeds measured as well as 10-minute standard deviations of wind azimuth σ_A and elevation angles σ_E at all measurement levels. Where more definitive information or data checks were required, detailed time-sequence data were also provided.

Time-sequential vertical profiles of wind speed and direction were plotted for each trial. Profiles for Trials 1-2, 1-3, 1-4 and 2-1, conducted in very light winds revealed that wind-direction shifts greater than 180 degrees occurred while the cloud remained on the grid. Because of these large variations in wind direction and, as might be expected, the large anomalies in the observed deposition patterns, these trials were excluded from the model validation. Table 5-1 shows the mean wind directions, wind speeds and other meteorological input parameters for the trials used for validation of the model.

The wind speeds shown in Table 5-1 are based primarily on the wind speeds measured on the towers. The wind directions were specified on the basis of the tower measurements and from an inspection of the isopleths of observed deposition for each of the trials. The isopleth deposition patterns for Trials 2-2R and 2-3, in which the flight path approximately coincided with the mean wind direction, were especially sensitive to the wind direction used in the model. For this reason, the wind directions for these trials were selected on the basis of the best match between observed and predicted deposition patterns, with all other inputs held constant.

Unrealistically large variations in σ_A and σ_E occurred in the tower measurements over 1-second intervals at several measurement heights, causing the vertical profiles of σ_A and σ_E to be erratic. For this reason, values σ_A and σ_E in Table 5-1 for a source function time τ of 2.5 seconds were not obtained from the tower measurements, but were selected on the basis of previous measurements of these parameters made at DPG during similar meteorological conditions (see

Table 5-1. Meteorological Inputs

Input	Trial				
	1-5	1-6	1-7	2-2R	2-3
Wind direction (degrees)	330	300	305	315	320
$\bar{u}$ (m sec^{-1})	3.0	1.0	1.8	4.0	4.2
H_m (m)	850	150	400	350	500
σ_A (deg) $\{\tau = 2.5$ sec$\}$	10	5	10	5	5
σ_E (deg)	10	5	10	5	3

Cramer, et al., 1972).

The values of the surface-mixing-layer depth H_m in Table 5-1 were primarily determined from the vertical profiles of wind direction and wind speed plotted from PIBAL measurements. In these profiles, the presence of wind-direction and wind-speed shears was used to define the bases of elevated stable layers limiting the vertical expansion of the spray cloud.

The vertical wind-direction shear term $\Delta\theta'/\Delta z$ in Equation 5-7 was set to zero for all trials. Wind-direction shear has little effect on the deposition patterns downwind from long line sources oriented perpendicular to the wind direction, as in Trials 1-5, 1-6, and 1-7. In Trials 2-2R and 2-3, where the flight path was approximately parallel to the wind direction, the wind-direction shear had little or no effect on the deposition pattern.

In accordance with our established procedures for nearly instantaneous releases, the lateral α and vertical β diffusion coefficients were set at 1.

5.4.2 Source Inputs

The fraction of the total spray weight released along the flight path in various drop-size categories was obtained from plots similar to Figure 2-2 showing cumulative mass versus drop size for each trial. The settling velocity V_{si} for the i^{th} settling-velocity category was calculated for the average drop size in each category using a technique by McDonald (1960), which considers the interaction of the drag coefficient and Reynolds number on the fall velocities of spheres. The mass fraction f_i and settling velocity V_{si} for each category are shown in Table 5-2 for each trial used in the model validation.

Values for the reflection coefficient γ in Table 5-2 for each drop-size category were obtained from Figure 5-6, which shows the curve relating settling velocity to the reflection coefficient. This curve, purely hypothetical, is based on the following general argument. It is assumed that all drops with settling velocities greater than 30 centimeters per second have a reflection coefficient of zero and are thus deposited on the ground without reflection. All drops with settling velocities less than 0.1 centimeter per second have a reflection coefficient of 1 and thus are not depositied on the ground but are completely reflected. Additionally, it is assumed that the reflection coefficient is linearly related to the settling velocity for velocities from 30 to 5 centimeters per second, with a value of 0.5 arbitrarily assigned to the reflection coefficient γ when the settling velocity is 10 centimeters per second. For settling

Table 5-2. Settling Velocities V_s, Fraction of Material f and Reflection Coefficients γ

Mean Droplet Diameter (μm)	V_{si} (m sec^{-1})	f_i	γ
Trial 1-5			
17.0	7.25×10^{-3}	8.00×10^{-3}	0.80
29.7	2.21×10^{-2}	1.65×10^{-1}	0.71
46.7	5.47×10^{-2}	3.02×10^{-1}	0.61
64.2	1.04×10^{-1}	3.96×10^{-1}	0.49
82.1	1.69×10^{-1}	8.20×10^{-2}	0.33
100.4	2.32×10^{-1}	3.33×10^{-2}	0.17
119.1	2.81×10^{-1}	9.70×10^{-3}	0.045
138.3	3.49×10^{-1}	3.40×10^{-3}	0.0
Trial 1-6			
25.2	1.65×10^{-2}	7.50×10^{-3}	0.74
37.4	3.67×10^{-2}	9.95×10^{-2}	0.66
53.3	7.46×10^{-2}	2.02×10^{-1}	0.56
69.2	1.26×10^{-1}	2.72×10^{-1}	0.44
85.1	1.90×10^{-1}	1.56×10^{-1}	0.27
100.9	2.41×10^{-1}	1.14×10^{-1}	0.145
116.7	2.84×10^{-1}	7.69×10^{-2}	0.035

(continued)

Table 5-2. Settling Velocities V_s, Fraction of Material f and Reflection Coefficients γ

Mean Droplet Diameter (μm)	V_{si} (m sec^{-1})	f_i	γ
Trial 1-6 (Continued)			
132.4	3.38×10^{-1}	3.63×10^{-2}	0.0
148.1	4.07×10^{-1}	2.83×10^{-2}	0.0
163.6	4.78×10^{-1}	5.90×10^{-3}	0.0
179.0	5.45×10^{-1}	1.30×10^{-3}	0.0
Trial 1-7			
25.2	1.67×10^{-2}	1.03×10^{-2}	0.74
37.4	3.67×10^{-2}	1.17×10^{-1}	0.66
53.3	7.46×10^{-2}	3.33×10^{-1}	0.56
64.2	1.26×10^{-1}	2.74×10^{-1}	0.44
85.1	1.90×10^{-1}	1.39×10^{-1}	0.27
100.9	2.41×10^{-1}	7.47×10^{-2}	0.145
116.7	2.84×10^{-1}	2.74×10^{-2}	0.035
132.4	3.38×10^{-1}	7.90×10^{-3}	0.0
148.1	4.07×10^{-1}	1.56×10^{-2}	0.0

(continued)

Table 5-2. Settling Velocities V_s, Fraction of Material f and Reflection Coefficients γ (concluded)

Mean Droplet Diameter (μm)	V_{si} (m sec^{-1})	f_i	γ
Trial 2-2R			
17.0	7.47×10^{-3}	9.80×10^{-3}	0.81
29.7	2.28×10^{-2}	9.55×10^{-2}	0.70
46.7	5.63×10^{-2}	3.36×10^{-1}	0.61
64.2	1.06×10^{-1}	3.35×10^{-1}	0.485
82.1	1.74×10^{-1}	1.22×10^{-1}	0.315
100.4	2.37×10^{-1}	6.75×10^{-2}	0.155
119.1	2.87×10^{-1}	2.57×10^{-2}	0.030
138.3	3.58×10^{-1}	9.70×10^{-3}	0.0
Trial 2-3			
17.0	7.34×10^{-3}	1.50×10^{-2}	0.81
29.7	2.24×10^{-2}	1.82×10^{-1}	0.71
46.7	5.54×10^{-2}	4.09×10^{-1}	0.61
64.2	1.05×10^{-1}	3.19×10^{-1}	0.50
82.1	1.71×10^{-1}	4.38×10^{-2}	0.295
100.4	2.34×10^{-1}	3.12×10^{-2}	0.165

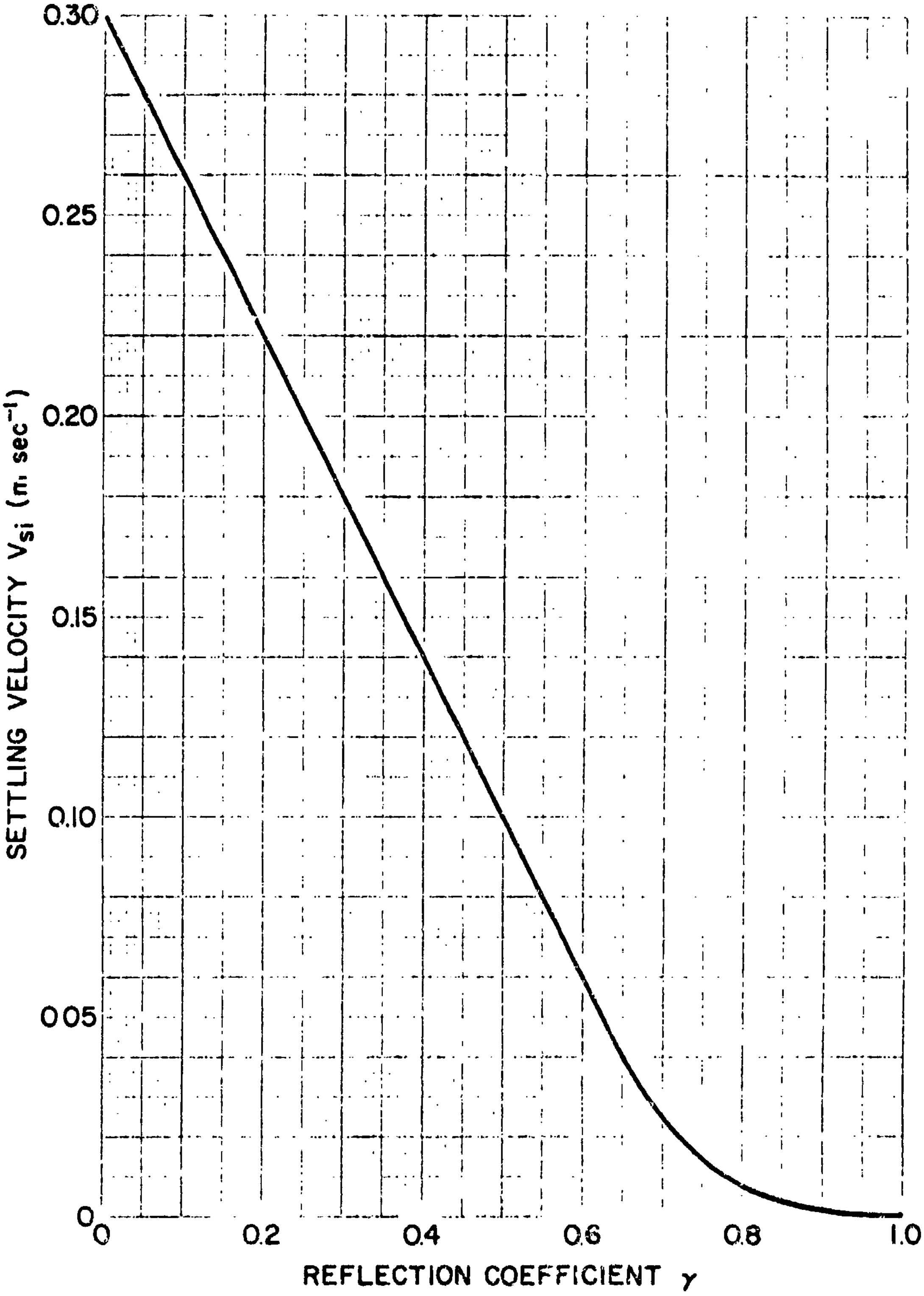


Figure 5-6. Relationship between the settling velocity V_{si} and the reflection coefficient γ at the ground

velocities less than 5 centimeters per second, the reflection coefficient asymptotically approached 1 as the settling velocity decreases to zero. Although other hypothetical relationships between the settling velocity and the reflection coefficient were tested, the curve shown in Figure 5-6 give the best agreement between the observed and predicted deposition for all trials when used in the deposition model.

The remaining source inputs required by the deposition model are given in Table 5-3. The total source strength, or total weight of the spray released along the line L, was obtained directly from dissemination data. The dissemination efficiency of the spray system was determined from analyses of the cylindrical (pipe-cleaner) sampler data from Tower 00 for Trials 1-5, 1-6, and 1-7. The total source strength Q_T and dissemination efficiency Eff shown in Table 5-3 were used in Equation 5-10 to define the source strength for each point source used in the line-source simulation. The dissemination efficiencies for Trials 1-5, 1-6, and 1-7 show that the efficiencies for Trials 1-6 and 1-7, in which the solvent Duphar was used, are nearly twice as large as the efficiency for Trial 1-5, in which No. 2 fuel oil was used. It is believed that this difference is due to the rapid evaporation of the more volatile components of the fuel oil. Since no dissemination-efficiency measurements were made for Trials 2-2R and 2-3, in which fuel oil was also disseminated, the efficiency for Trial 1-5 was used for these trials in the model validation.

The value for the lateral source dimension σ_{y_L} (see Equation 5-11) is important in the deposition calculations only when the flight path is parallel to the mean wind direction. The value of σ_{y_L} was estimated for the inwind trials 2-2R and 2-3 under the following assumptions:

- All spray material is initially contained in the six vortices formed by two wing tips and four engines

- The engine vortices quickly combine with the wing-tip vortices to form two large vortices, one on each side of the flight path; these two vortices sink toward the ground and combine to form a single large ring vortex

- The distribution of spray material within the ring vortex thus formed behind the aircraft is Gaussian, and the concentration at the edge of the ring vortex is one-tenth of the concentration at the center

Using procedures given by Jones (1970), the sink rate for each wing-tip vortex was calculated to be approximately 1 meter per second. Also, the initial lateral separation of the two wing-tip vortices is

Table 5-3. Source Inputs

Source Parameter	Trial				
	1-5	1-6	1-7	2-2R	2-3
Q_T (g)	4.040×10^5	2.174×10^5	9.195×10^4	2.950×10^5	1.035×10^5
Eff	0.501	0.927	1.00	0.501	0.501
L (m)	1.408×10^4	7.376×10^3	7.488×10^3	1.028×10^4	8.662×10^3
H (m)	15	15	15	46	27
σ_{zR} (m)	22.3	35.8	35.8	15	15

given by the wing span of the DC-7B aircraft, which is approximately 28 meters. As explained in Section 5.2.3, the wing-tip vortices continue to sink toward the ground until they touch the ground. Assuming the aircraft altitude to be 50 meters above the ground during release and a sink rate of 1 meter per second, the wing-tip vortices touch the ground and stop sinking approximately 40 to 60 seconds after the passage of the aircraft. At this time, the lateral dimension of the large ring vortex formed by the combination of the two wing-tip vortices and the four engine vortices is estimated to be three wing spans, or about 84 meters. The value for σ_{yL} is obtained by dividing this lateral dimension by the Gaussian distribution factor of 4.30 to yield a value of approximately 20 meters. This value for σ_{yL} was used in all the model calculations.

The vertical dimension of the spray cloud σ_{zR} and the effective source height H for Trials 1-5, 1-6 and 1-7 were estimated from inspection of the vertical profiles of dosage obtained from the cylindrical samplers mounted on Tower 00. The vertical dosage profile for Trial 1-5 exhibited a peak dosage at about 15 meters above the ground, and the dosage dropped to zero at about 63 meters above the ground. In this case, the effective source height was set at 15 meters, and the vertical source dimension was obtained by dividing the difference between 63 and 15 meters (48 meters) by 2.15 to obtain a σ_{zR} of 22.3 meters. The vertical dosage profiles from Tower 00 for Trials 1-6 and 1-7 were relatively invariant with height, but the top of the spray cloud appeared to be about 92 meters. In the absence of more definitive information, the effective source heights for these trials were also set at 15 meters, and σ_{zR} was set at the difference between 92 and 15 meters divided by 2.15, or 35.8 meters. For the inwind trials 2-2R and 2-3, the effective source height was set at the aircraft height, because the mean wind speeds were approximately four times larger than the vortex sink rate of 1 meter per second. The value for σ_{zR} assigned to the inwind trials was 15 meters.

5.5 COMPARISON OF CALCULATED AND OBSERVED DEPOSITION PARAMETERS

Profiles of calculated and observed deposition versus distance for five trials are presented in Section 5.5.1, below. As explained in Section 5.4, deposition profiles were not calculated for the remaining trials because of large variations in the spray rate or large shifts in wind direction. The calculated profiles were obtained by using the deposition model described in Section 5.3 with the meteorological and source inputs given in Section 5.4. Observed profiles were obtained by the procedures outlined in Section 5.2.2. A summary of the results of the model validation is provided in Section 5.5.2, below.

5.5.1 Calculated and Observed Deposition Profiles

Profiles of calculated and observed deposition for the trials 1-5, 1-6 and 1-7, where the flight path was nearly perpendicular to the mean wind direction, are shown in Figures 5-7, 5-8 and 5-9, respectively. In the figures, the solid line represents the observed-deposition profile, and the dotted line represents the calculated-deposition profile, for a reflection coefficient γ of zero (all drops intersecting the ground are assumed to be retained). The dashed line represents model calculations made under the assumption that the spray material is partially reflected at the ground, according to the values of γ presented in Table 5-2.

Figure 5-7 shows that the model calculations made under the assumption of partial reflection agree with the observed deposition profile more closely than the model calculations made under the assumption of total deposition. The secondary maximum about 6 kilometers downwind from the flight path is from drops reflected at the top of the surface mixing layer toward the ground surface.

The agreement between observed and calculated deposition is not as good for Trial 1-6 as in Trial 1-5. Wind speeds recorded at all heights on Tower 00 averaged only about 1 meter per second for Trial 1-6, and the wind directions were considerably more variable than in Trial 1-5. During the first half hour after dissemination, the wind directions and speeds measured on Tower 00 indicate the cloud moved slowly down the sampling grid. During the next half hour, wind directions measured on Tower 00 became more westerly. No meteorological measurements were recorded from Tower 00 beyond 1 hour after dissemination. Notations in the logbook of the test officer conducting Trial 1-6 may explain the sharp drop in observed deposition shown in Figure 5-8 beyond about 3 kilometers from the flight line and the fact that the observed deposition is larger than the calculated deposition between 1 and 3 kilometers from the flight line. A note in the logbook, made at about an hour and a half after dissemination began, indicates that the wind near the flight line during the last 20 minutes was from the south and west. Thus, about 1 hour after dissemination, the wind direction near the flight line was almost the reverse of the direction measured at the time of dissemination. Assuming a mean cloud-transport speed of 1 meter per second, the cloud should have been about 2.7 to 3.6 kilometers from the flight line 45 minutes to 1 hour after dissemination. Since the wind shift could easily have occurred earlier than 1 hour after dissemination at this distance from the flight line, the cloud could have easily reversed directions at this point and moved back toward the flight line. This reversal in cloud-transport direction would increase observed deposition in the region from 1 to 3 kilometers from the flight line and would explain the sharp decrease in observed deposition

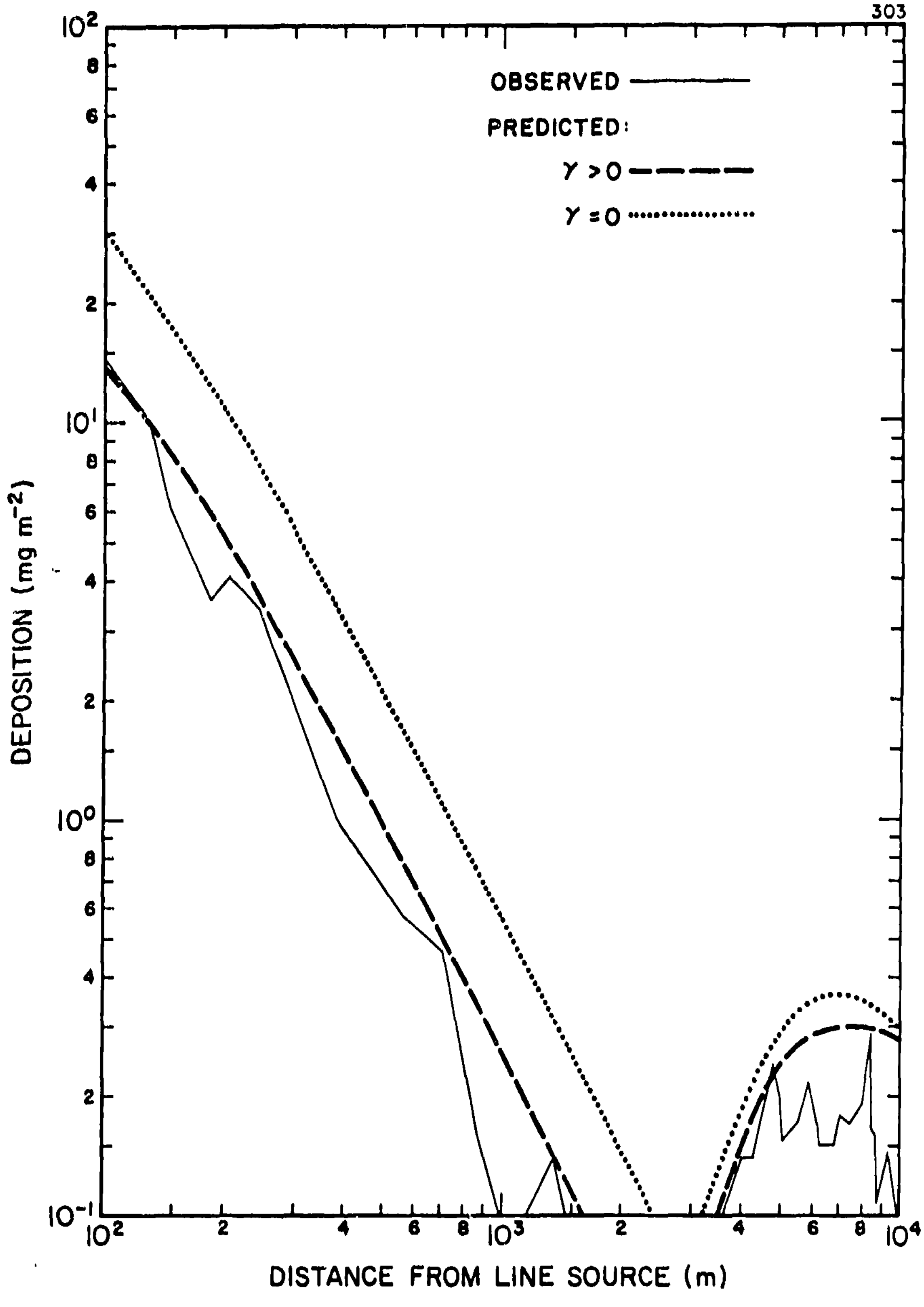


Figure 5-7. Observed and predicted deposition in Trial 1-5.

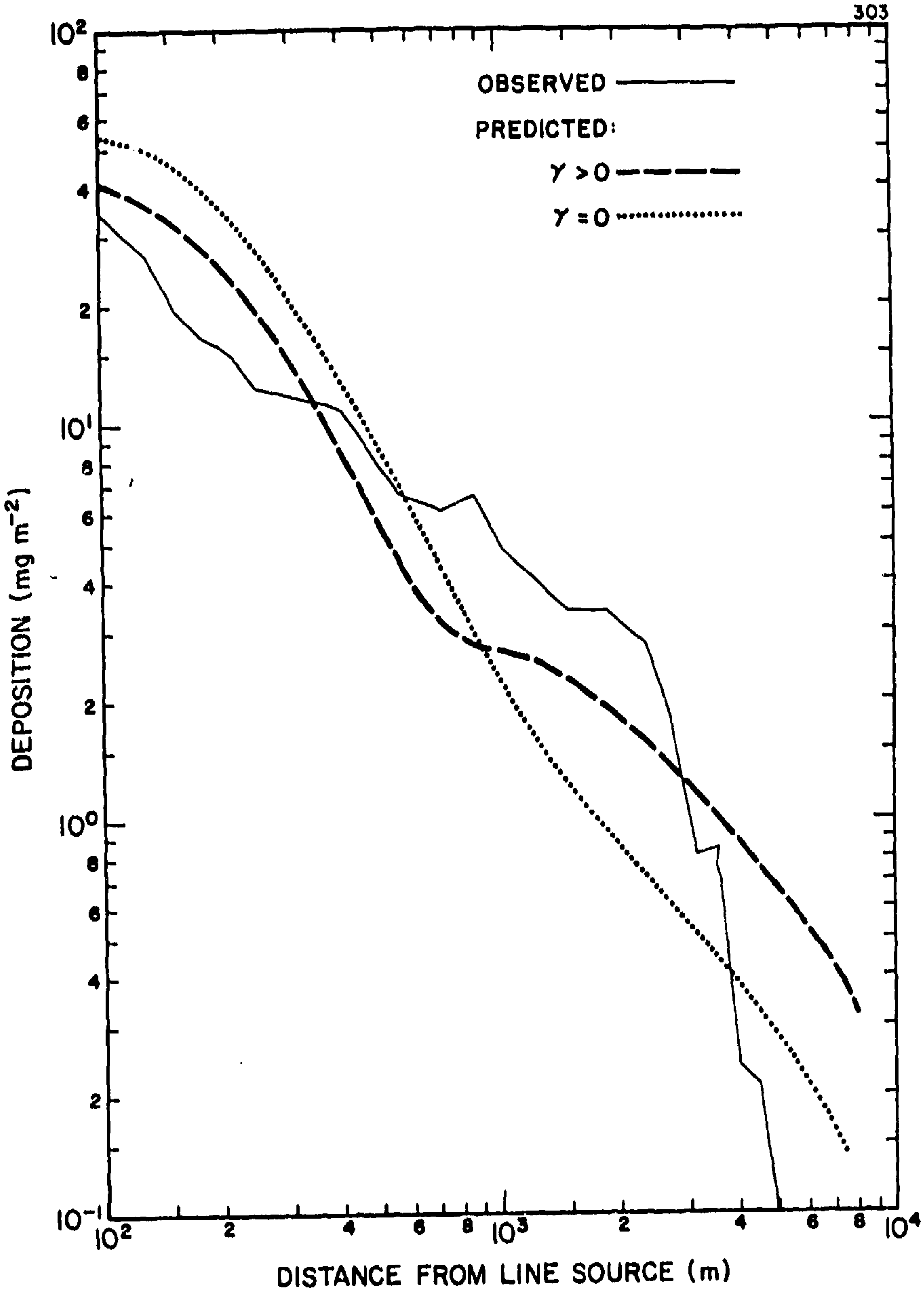


Figure 5-8. Observed and predicted deposition in Trial 1-6.

beyond that distance. According to the test officer's logbook, crews began picking up the deposition samplers, beginning at the flight line and moving downgrid, about 1 hour after dissemination began.

Figure 5-9 shows good agreement between observed and calculated deposition for Trial 1-7. Again, the calculated profile assuming partial reflection of drops at the surface agrees with the observed deposition better than the profile calculated by assuming total deposition or zero reflection. The secondary deposition maximum from reflection at the top of the mixing layer is also apparent. Since the mixing depth is smaller in Trial 1-7 than in Trial 1-5, the secondary maximum in Trial 1-7 occurs closer to the flight line and is larger than the secondary maximum for Trial 1-5.

Profiles of calculated and observed deposition for Trials 2-2R and 2-3, where the flight path was nearly parallel to the wind direction, are shown in Figures 5-10 and 5-11. Because the flight path is approximately parallel to the wind direction, deposition occurs on both sides of the flight path. For this reason, calculated and observed deposition patterns are shown in the figures for both the left and right sides of the flight path. The deposition profiles for Trials 2-2R and 2-3 show that deposition occurred at greater distances to the right than to the left of the flight path. In both trials, the flight path was not directly into the wind, but slightly to the right or clockwise from the mean wind direction.

The calculated deposition profiles agree remarkable well with the observed deposition profiles, especially for Trial 2-3. For Trial 2-2R, Figure 5-10 shows good agreement between calculated and observed deposition to the right of the flight path, but the calculated deposition to the left of the flight path is slightly greater than the observed deposition. Since the flight paths are almost into the mean wind direction, secondary deposition maximums from the reflection of spray drops from the top of the surface mixing layer do not occur within the boundaries of the sampling network. For Trials 2-2R and 2-3, the deposition profiles calculated under the assumption of partial reflection fit the observed profiles better than profiles calculated assuming zero reflection.

5.2.2 Summary of Results

In the use of deposition modeling techniques to characterize the spray deposition observed during the spray trials, attention was centered on the five trials (three crosswind and two inwind) for which complete sets of satisfactory measurements were available. The remaining five trials were excluded from consideration because of uncertainties in the spray-metering system and anomalous deposition patterns caused by large shifts or reversals in wind direction after release.

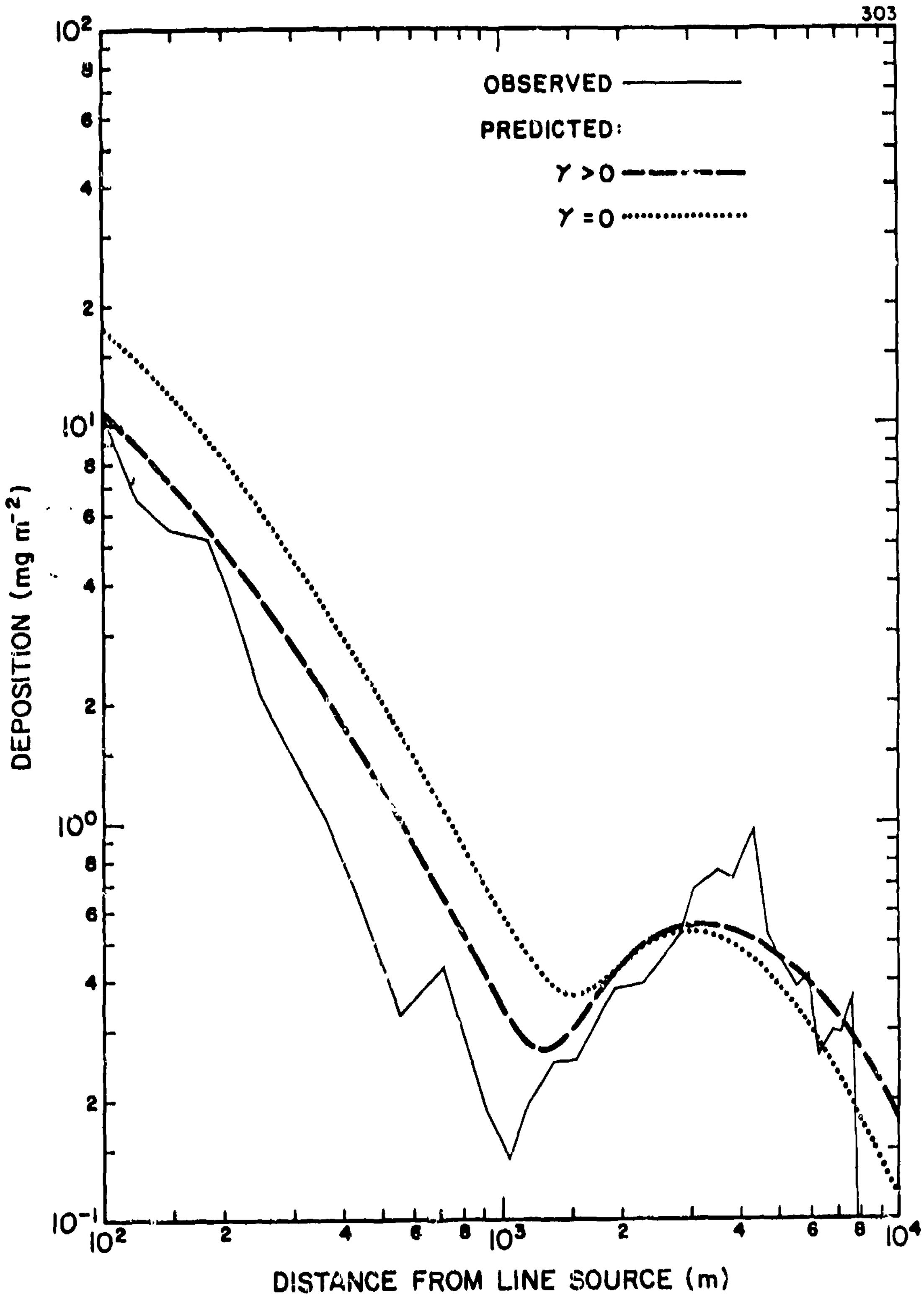


Figure 5-9. Observed and predicted deposition in Trial 1-7.

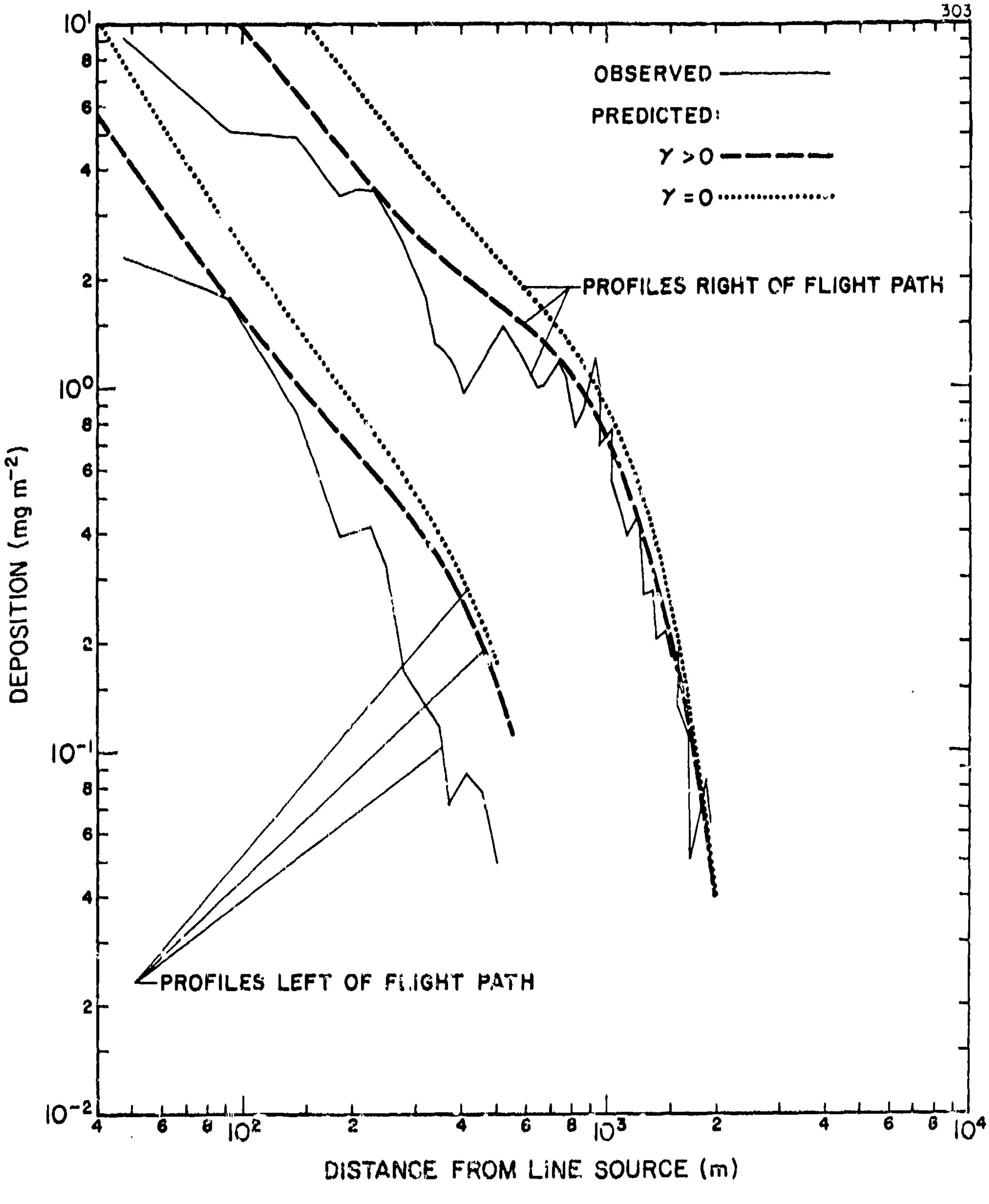


Figure 5-10. Observed and predicted deposition in Trial 2-2R.

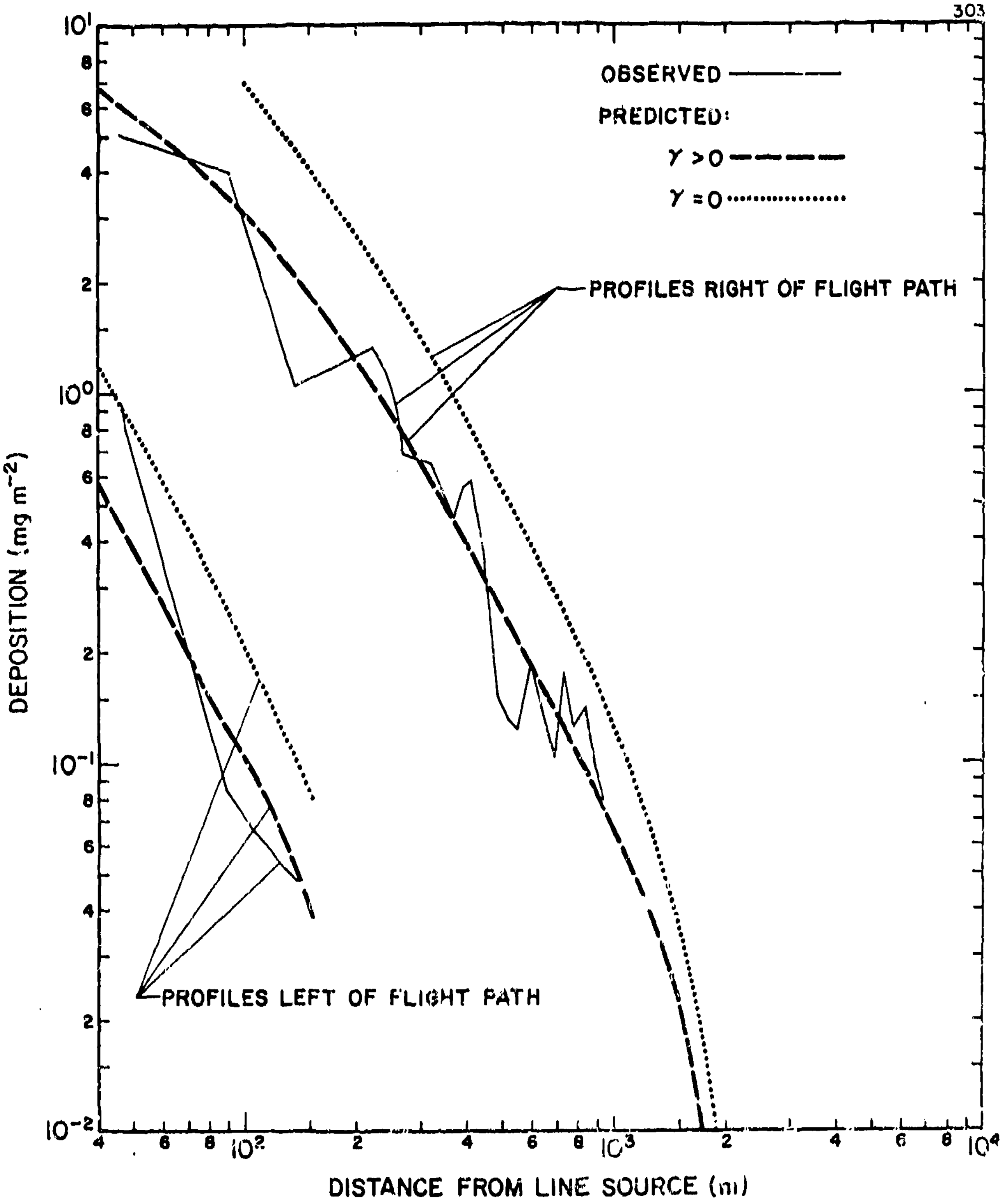


Figure 5-11. Observed and predicted deposition in Trial 2-3.

For these five trials, it has been possible to characterize the deposition pattern produced by the spray system beyond 100 meters from the flight path, by a generalized deposition model for elevated line-source releases using source and meteorological inputs derived from measurements made during the trials. Source inputs for the three crosswind trials were principally obtained from the geometry and composition of the spray cloud a few minutes after the passage of the aircraft as revealed by analyses of spray collections on the 94-meter tower approximately 100 meters downwind from the flight line, aircraft data and drop-size distributions based on the counting and sizing of drop stains on Printflex-card samplers.

No attempt was made in this study to calculate, for any of the five trials, the deposition pattern directly below the flight path. This requires a detailed knowledge of the structure of the trailing vortices and the interactions of this vortex system with the spray droplets and the atmosphere during the first 60 to 100 seconds after the spray is discharged.

One of the new features of the generalized deposition model involved partial-reflection coefficients, which depend on drop size and settling velocity. The partial-reflection coefficients were used to determine, for each drop-size category, the fraction of the spray deposited on the ground. Specific values for the partial-reflection coefficients used in this study may not apply to other sites where the properties of the ground are different. This question can probably be answered only by conducting similar field experiments at other locations.

It is important to note that the success of the generalized deposition model in characterizing the deposition pattern strongly implies that the downwind drift of the spray clouds may also be successfully modeled. Because of time limitations and the fact that no measurements of downwind drift were made, model calculations of downwind drift were not attempted. However, these calculations can be made by using the generalized concentration-dosage model for elevated line-source releases, with a vertical term that includes both settling and partial relfection. This model is available in computerized form and has been successfully used in recent work for DPG.

Only a relatively small number of trials were conducted and some important types of measurements, such as downwind drift, were not included. However, the results clearly demonstrate the feasibility of quantifying the performance of the DC-7B spray system with respect to deposition patterns and downwind drift through the use of modeling techniques in combination with similar field-measurement programs.

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APPENDIX A - ASSESSMENT TECHNIQUES

The analytical chemical methods, droplet sizing and counting procedures, and data reduction schemes used to evaluate the empirical results generated on this test are delineated herein.

1. Determination of Physical Properties of Duphar

Selected physical properties of Duphar were requested by FAO to permit evaluation of the data acquired in Trials 1-6 and 1-7. The properties listed in Table A-1 were determined for the unknown Duphar sample supplied by the test sponsor using guidelines set forth in American Society for Testing and Materials (ASTM) Standard Designation, Parts No. 17 and 18.

2. Gas Chromatography Analysis of Endosulfan

A gas chromatography (GC) method for the analysis of Endosulfan was developed for support of Trial 1-5. Analytical techniques and operational parameters for the analysis were as follows:

a. Apparatus. A Hewlett-Packard Model 5713A gas chromatograph equipped with an 8-foot stainless-steel column having a 1/9-inch inside diameter (packed with 5 percent SP-2401 (QF-1-on 80/100 mesh Chromosorb 750) and a 63_{Ni} constant current election capture detector was utilized for the analysis of Endosulfan. Chromatography was conducted at column and detector temperatures of 235° C and 300° C, respectively, and at a carrier (10 percent methane in argon, commonly called T gas) flow rate of 35 milliliters per minute. A digital integrator (autolab Model IV) was used to determine peak areas and retention times. The integrator times were: T1 = 50 seconds; T2 = 325 seconds; and T4 = 400 seconds. The slop sensitivity (SS) was 200, and the peak width (PW) was 7.

b. Internal Standard Solutions. The solution consisted of 0.5 microgram per milliliter of Aldrin in n-heptane.

c. Sample Solutions. Endosulfan (provided by the FAO representative) was dissolved in n-heptane over a concentration range of 0.01 to 5.0 micrograms per milliliter.

d. Procedure. Three microliters of sample solution were injected into the sampling port using a Hewlett-Packard auto injector.

e. Results:

(1) The retention time for Aldrin was 79 seconds. The retention times for Endosulfan were 128 and 197 seconds (Endosulfan occurs at two insomers: Endosulfan I, with melting point of 106° C, and Endosulfan II, with melting point of 212° C). Attempts to speed the analysis times by unresolving the two peaks with a short nonpolar column were unsuccessful.

(2) A small carryover was observed after inspection of sample solutions having high concentrations (5 micrograms per milliliter); hence, the maximum wash cycle was used. A significant reduction in response was encountered when sample solutions of 6 to 10 micrograms per milliliter were analyzed; therefore the range of the Endosulfan analysis was restricted to a concentration range of 0.01 to 5.0 micrograms per milliliter.

(3) A precision run of 53 standards was made in the 0.01 to 5.0 microgram-per-milliliter range. Regression analysis of the run indicated a correlation coefficient (R) of 0.999862. The standard

Table A-1. Comparison of Selected Physical Characteristics of Duphar and Fuel Oil No. 2

Physical Property	Fluid: Fuel Oil Number 2	Fluid: Duphar	AMSTE Test Method and Modifications
Density (g/ml) at 20° C	0.847	0.87	10 ml pycnometer
Flash Point (°C)	38	111	Closed cup ASTM D93 - 66 & E134 - 64
Kinematic Viscosity (Centistokes at 25° C)	4.3	8.3	ASTM D445 - 65 & D2162 - 64
Evaporation Loss			
Temp ° C	11	11	ASTM D972 - 56
Evaporation Loss (% wgt)	18.36	0.19	a. The evaporation cell was a rectangular glass
Time of Exposure (hours)	76.5	74.5	(23.4 mm wide x 7.5 mm high x 187.0 mm long) Total
Evaporation Loss (% hr)	0.24	2.56×10^{-5}	volume of the cell was 32.82 cc.
Temp ° C	24.4	24.4	b. Experimental parameters: The cell was placed in
Evaporation Loss (% wgt)	14.57	0.63	a water bath maintained at the recorded temperature
Time of Exposure (hours)	68.6	64.22	and filtered dry air was passed through the cell by
Evaporation Loss (% hr)	0.21	9.78×10^{-3}	a vacuum. The flow was controlled by an orifice calibrated for a flow rate of 2ℓ/min.

[a] All data except evaporation loss obtained from Chemical Engineers Handbook, Perry and Chilton, 5th Edition, McGraw-Hill.

Note: The dye content of fule oil number 2 and Duphar were 0.48 and 0.58 percent, respectively.

deviation for each of six sample solution concentrations is given below:

Endosulfan Concentration (ug/ml)	Standard Deviation
0.01	0.0143
0.05	0.0081
0.10	0.0165
0.50	0.0046
1.00	0.0015
5.00	0.0211

(4) Endosulfan was extracted from each sample collected from the vertical sampling tower (five pipe cleaners) using amixture of 10 milliliters of n-heptane spiked with Aldrin at the rate of 0.5 microgram per milliliter, plus 10 milliliters of 0.1 normal (0.1N) sulfuric acid. The single pipe cleaners collected from the downwind sampling line were extracted using a mixture of 5 milliliters of n-heptane spiked with Aldrin at the rate of 0.5 microgram per milliliter plus 10 milliliters of 0.1N sulfuric acid.

(5) A correction factor to adjust the Endosulfan concentration values obtained from field samples for extraction losses during sample preparation was developed. The GC analysis results gave uncorrected concentration values between 0.01 and 1.44 micrograms per milliliter. Extraction efficiency was run on known Endosulfan concentrations of 0.1, 1.0, and 10.0 micrograms per milliliter. It was obvious that the relationship between concentration and extraction efficiency was not linear; however, over small increments, a linear model was acceptable. The data-extraction efficiency was:

Concentration (g/ml)	0.1	1.0	10.0
Extraction (percent)	86.6	97.4	99.2

Since 1.44 micrograms per milliliter was the highest sampler value encountered, it was decided to fit a linear model using only extraction data from concentrations of 0.1 and 1.0 microgram per milliliter.

The linear model used was of the form:

$$y = a + bx$$

where: y = correction factor or reciprocal of proportion of Endosulfan extracted

a = intercept

b = slope

x = log of concentration

Using the two-point equation, we obtained:

$$y = 1.03 - 0.12x$$

Caution should be exercised in using the above function for values much above 1.0 microgram per milliliter.

3. Meteorological Data Reduction

a. Wind speed and direction were measured and recorded as 1-second instantaneous values and averaged at 30-second intervals from 5 minutes before release time until the cloud passed the downwind perimeter for the sampling grid (based on the mean cloud-transport speed).

b. Horizontal and vertical components of wind direction were measured and recorded as 1-second instantaneous values and computed at 5-minute standard deviations of the wind azimuth (σ_A) and standard deviations of the elevation angle (σ_E).

c. The height of the mixing layer was computed using the rawinsonde data.

d. Standard surface observations were measured and recorded by the meteorologist in charge.

e. The combination of all meteorological data was used to define the mean layer wind velocity, mean transport speed of the droplet cloud, and other pertinent meteorological parameters required for mathematical modeling.

4. Ultraviolet (UV) Spectrography Analysis of CI 258 Dye in Field Samples

The pipe cleaner and filter-paper samplers used in this project were inserted in test tubes and the dye extracted using 15 milliliters and 30 milliliters of isopropyl alcohol, respectively. The samples were then shaken 1 hour (via electric shaker). Aliquots were taken and analyzed by UV spectrography using the following method:

a. Equipment. Spectra scans were obtained with Beckman (Model DV) recording spectrophotometer using 4-cm quartz cells (flow-through type) and linear wavelength and absorbance with digital print-out. Calibration was achieved using prepared standard solutions having CI 258 dye values of 0.0, 0.25, 0.5, 1.0, and 2.5 micrograms per milliliter. The relationship of dye concentration to absorbance was linear.

b. Analysis. CI 258 dye concentration can be determined by UV spectrometry at 512 millimicrons in a 4-cm cell over a nominal concentration range of 0.5 to 2.5 micrograms per milliliter with a lower detection limit of 0.3 microgram per milliliter. The average sensitivity of the analysis was 0.34 absorbance unit per microgram per milliliter (or 340 chart units per microgram per milliliter).

c. Deposition Density Estimates. Dye concentration values (in micrograms per milliliter) were converted to deposition density (mg/m^2) using the following scheme:

$$\text{Deposition Density } (mg/m^2) = \frac{(GR-LB)}{(S)} \frac{(DF)}{(A)} \frac{(SV)}{(0.1)}$$

where: GR = Gross reading (γ/ml)

LB = Value of laboratory blank (γ/ml)

DF = Dilution factor

SV = Solution volume (ml)

S = Sensitivity

A = Area of sampling surface

d. The amount of dye recovered by pipe cleaners (in mg/m^2) were estimated as follows:

$$\text{Recovery } (mg/m^2) = \frac{(GR - LB)}{(S)} \frac{(DF)}{(A)} \frac{(SV)}{(0.1)}$$

where: $A = 4.54\ cm^2$

NOTE: When five pipe cleaners were used, the above area (A) was multiplied by 5.

5. Estimation of Drop-Stain Relationship of Dyed Fuel Oil No. 2 and Duphar for Printflex-Card Samplers.

The relationship of droplet diameter to stain size for dyed Fuel Oil No. 2 and dyed Duphar was determined using the following sequence:

a. Droplets of 10 to 350 microns were generated as described below and deposited on Printflex cards.

b. The stains were sized using three techniques: (1) visually, with a laboratory microscopic; (2) visually with a 7X measuring magnifier; and (3) instrumentally by Quantimet at Los Alamos Laboratory. Selected trials were also processed using the automatic spot counter and sizer (ASCAS).

c. The data were fitted to a second-order regression equation to obtain the relationship of droplet diameter to stain size. Comparisons were made of the three data sets, and the visual method utilizing the 7X measuring magnifier was selected as the standard. The magnifier values were weighed against the microscope values to obtain a realistic regression line. Detailed descriptions of droplet-generation and sizing and counting techniques follow.

6. <u>Techniques of Generation, Capture. Sizing, Transfer and Measurement of Droplets and Stains - The Salomon Technique</u>[a]

a. Generation of Aerosol: A heterogeneous aerosol of droplets was generated by an inexpensive apparatus commonly employed for spraying chromatograms with developing agent (e.g. Quixspray, Cole-Parmer Instrument Co., Chicago, Illinois, Catalog No. 9830). Basically, this consists of a small jar containing the fluid to be aerosolized, connected to a replaceable can of propellant (Figure A-1). The Cole-Parmer equipment is more versatile than the "blown needle" generator in the range of viscosities it will accommodate. The "blown needle," of the type described by W.R. Lane, J. Sci. Instc, 24, 98 (1947) (supplied through the courtesy of M.B. Fromm, Edgewood Arsenal) affords a source of homogeneous droplets. It has also been used successfully in this application. It is a much less efficient source of droplets and far more difficult to construct and maintain, but does have the advantage of predictability of particle diameters. For special circumstances, the latter factor may become a sufficiently important advantage to warrant adoption of such an aerosol generator. In the present work, this was determined not to be the case.

b. Capture of Droplets: The aim was to capture droplets on the apex of a V-shaped wire and subsequently to measure the diameter of the droplet and transfer it to suitable paper stock (such as Printflex-cards). Since the efficiency of the generator is visibly good in terms of numbers of droplets disseminated per unit of time or volume of air, the probability of capture of a droplet in a matter of seconds was found to be excellent. The size of the captured droplet cannot be controlled without the blown-needle apparatus. However, by moving the V-shaped wire

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[a] Technique developed by Dr. Lothar L. Salomon of Dugway Proving Ground (to be published).

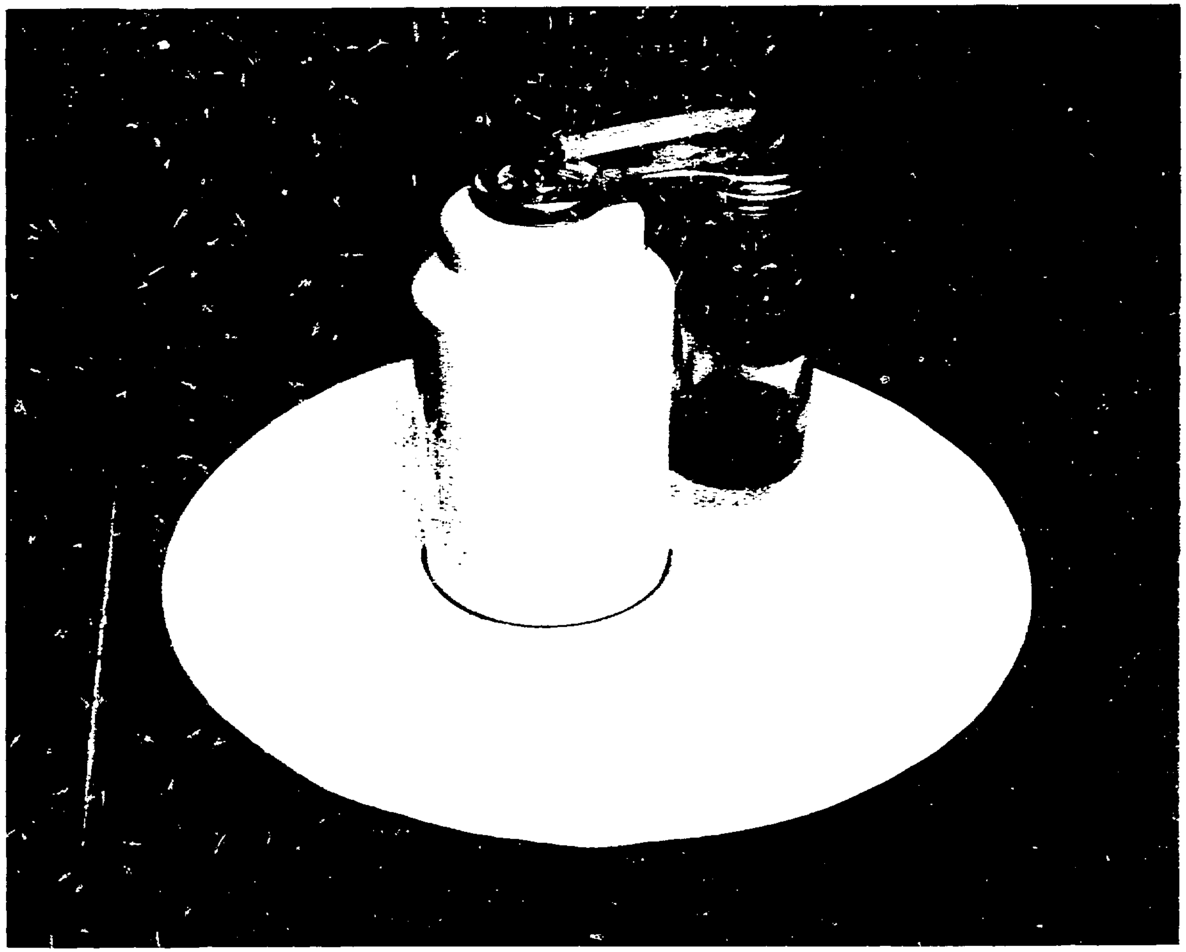


Figure A-1. Photograph of Quixspray Aerosol Generation Apparatus

into or out from the center of the cone-shaped spray, or moving it nearer to or farther away from the nozzle, the probability of trapping a larger or smaller droplet is enhanced. For efficiency, several wire holders were suspended on a rack, V-shaped wire downward, and exposed simultaneously.

c. Determination of Droplet Size. The wire holders were attached to a microscope stage using a spring clamp, with the apex of the V-shaped wire downward (see Figure A-2). The diameter of the droplet was then measured using a 50-division eyepiece micrometer (graticule) calibrated against a stage micrometer (2 mm divisions divided into units of 0.01 mm, American Optical Co., Buffalo, NY) at 250X magnification or the graticule described by G.L. Fairs, Chemistry and Industry, 62, 374 (1943). Each combination of graticule, eyepiece and objective lens was calibrated separately. The purpose of orienting the V-shaped wire as described was to permit detection of deformation in the droplets. However, over the range of sizes employed, up to approximately 350 μm diameter, droplets appeared to be perfectly spherical except when diameters are 15 μm or less. The 5 μm wire used to trap droplets (tungsten wire, Goodfellow Metals, Ltd., Ruxley Towers, Calygate, Esher, Surrey, England KT10 OTS) contributes to the volume of the droplet and thus tends to cause over-estimation of the diameter

The corrected diameter (d) can be approximated by

$$d = \sqrt[3]{d'(d'^2 - 37.5)}$$

where d' is the measured diameter of the wire-suspended droplet. Corrections are not appreciable except for very small droplets, as seen in the following table.

Measured d' (m)	Corrected d (μm)	Overestimate (% of d)
10	8.55	17
15	14.1	6
18	17.3	4
21	20.4	3
30	29.6	1

d. Transfer to Paper Stock. After the diameters of trapped droplets were determined, the droplets were transferred to the paper stock used for deposition sampling in the field (see Figure A-3). This transfer required careful technique and steady hand to avoid touching the wire itself to the paper (which will distort the stain). A suitable magnifier (e.g., the optivisor with 3.5X magnification, from LA Pine Scientific Co., or magnifier with spot illuminator and 3X magnification from Cole-Parmer Instrument Co.) is virtually indispensable. Each resultant stain was marked for identification. If the droplet consists of a fluid with significant vapor pressure, rapid transfer to the paper

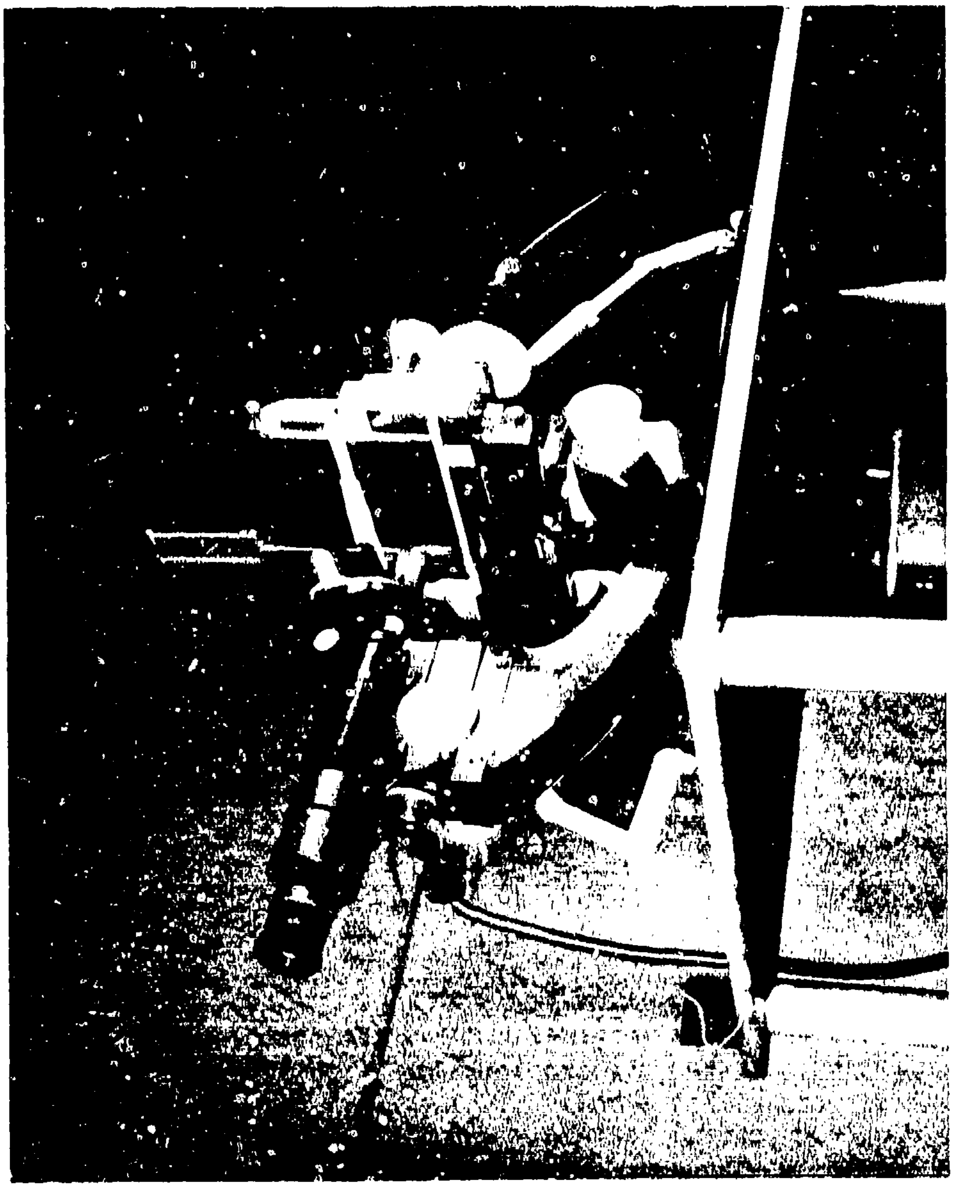
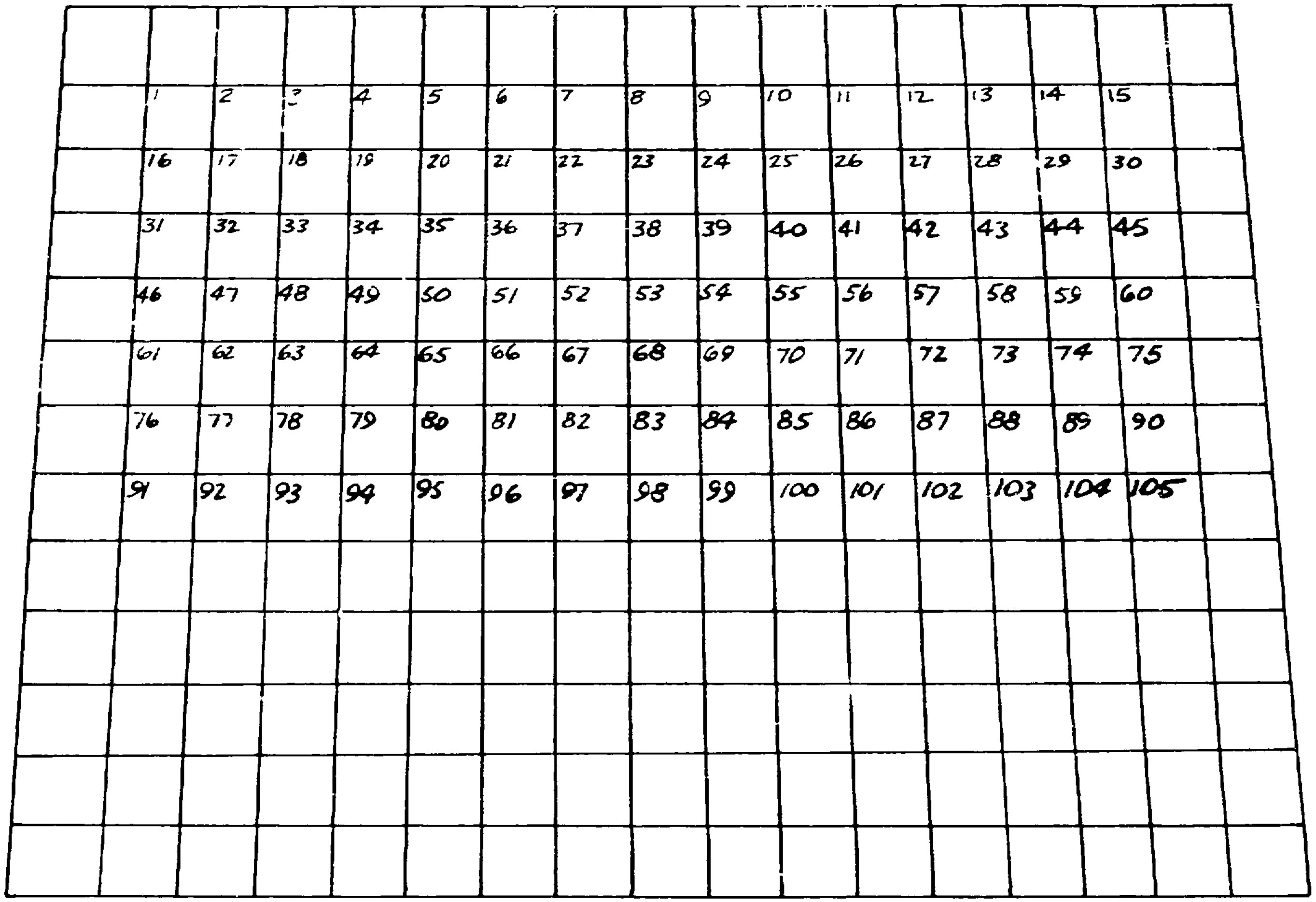


Figure A-2. Microscope Setup for Sizing of Droplets in DPG Laboratory



Grid spacing: ½ inch

Figure A-3. Stock Paper Prepared for Transfer of Droplets

after measurement of the diameter is essential. (The rate of evaporation can be minimized by working at low temperatures and in an enclosure saturated with vapor of the given fluid.)

e. Measurement of Stains and Spread Factors. After 24 hours, to permit diffusion of the fluid within the paper, stains were measured microscopically at 50X magnification, essentially to determine droplet diameters. The microscope stage was in the normal horizontal position, and the paper was illuminated from above.

In many instances, the stain was not circular, because of variation in the orientation of the fibers or structure of the paper. Therefore, two measurements were made routinely to determine the long and short axes (a and b) of the elliptical stain. The diameter d of a circular stain was then established using the relationship.

$$d = ab$$

Most often, a and b do not differ greatly. In general, when the V-shaped wire touches the paper during transfer of droplets, a and b are grossly different, and the stain is useless for determining stain factors.

Ratios of the diameters of stains to droplet diameters are the "stain factors." For No. 2 fuel oil and Duphar Solvent D, over the sizes examined the stain factors are not linearly related to droplet diameters.

f. Estimation of Droplet Diameter from observed stain size. The drop diameter was determined by the method described in section 6.c, Appendix A. The stain diameter was found by the manual method using 7X measuring magnification. The data obtained were fitted to a second-order equations of the form:

$$y = a + bs + cs^2$$

where: y = drop diameter

s = stain diameter

a, b, c are regression coefficients

The resulting equation for dyed fuel oil No. 2 is:

$$y = 12.19 + 0.1221S + 1.044 \times 1\text{-}^{-5}\ S^2$$

The resulting equation for dyed Duphar is:

$$y = 20.53 + 0.1193S - 0.2213 \times 10^{-5} S^2$$

7. Droplet Assessment Using 7X Measuring Magnifier

The same droplet cards assessed by the laboratory were assessed using a 7X measuring magnifier. The Printflex cards from all acceptable trials were also assessed using the following techniques:

a. The cards received from the laboratory contained 60 to 130 stains (each stain enclosed in a penciled square and numbered). Each stain was sized and the measurement obtained and recorded according to the numerical identity of the droplet. These values were than used to compare the laboratory and manual techniques of stain sizing to isolate operator bias and to permit weighting of the second-order equation relating droplet diameter-stain size. Details of this statistical comparative analysis are in Chapter 4.

b. Printflex cards (identified by grid position) received from each field trial were assessed in the following manner.

(1) Each sampler was visually inspected and the deposition density classified as light, medium or heavy. The stain distribution was also observed, to isolate atypical characteristics (if all stains were located on a portion of a sampler, it may indicate that the sampler was not placed at the sampling station properly).

(2) A Printflex card with a square cut out of the center (measuring 6.81 centimeters on a side) was placed on the sampler to be assessed. The size of the cutout was based on the fact that a 1-square centimeter section of 35 mm film is processed using the DPG automatic spot counter and sizer (ASCAS). This 1 x 1-centimeter section, when adjusted by the photoreduction factor, is equivalent to an area measuring 6.81 to 6.81-centimeters on a Printflex-card sampler. Subsequent ASCAS versus visual stain assessments can be compared, since the sections processed are equivalent.

(3) Sixteen stain-size categories were selected, based on the range of stain sizes exhibited in the field trial. The categories selected were used for all assessment methods to permit statistical comparisons.

(4) Each stain within the cutout was sized by category for all samplers exhibiting light deposition ($\sim$150 to 250 stains). The cutout was divided into seven vertical sections (each approximately 1 cm wide) marked, and the value recorded for each section.

(5) Assessment of cards exhibiting medium deposition (approximately 300 to 1000 stains) was limited to one-half of the cutout. This portion was divided into seven vertical segments (lines drawn at 0.5-centimeter intervals). Each stain in each segment was sized by category, marked and recorded.

(6) Assessment of cards exhibiting heavy deposition ($\geq$1,000 stains) was limited to one-fourth of the cutout. This portion was sectioned into seven vertical segments (with vertical lines drawn at 0.25-cm intervals). Each stain in each section was sized by category, marked and recorded.

(7) The size-count summary for all cards associated with a given trial were submitted for evaluation of the droplet spectra (see Paragraph 8.c).

8. <u>Droplet Assessment Using ASCAS</u>

a. Operation. The droplet stains on the collecting cards were photographed. (Unfortunately, debris or smudges on the cards were also photographed and were later indistinguishable from mixture stains. This introduced an irremediable error; all errors of the ASCAS procedure were reconciled, as will be discussed in the following paragraphs.) Sixteen size intervals ($0\text{-}S_1$, $S_1\text{-}S_2$, . . . , $S_{15}\text{-}S_{16}$) were selected to cover all stain diameters on the cards of the given test. A small section of the film (1 x 1 cm) was counted, and the spots were grouped into the 15 size intervals. The machine uses a "flying spot scanner," which scans the picture in approximately 1,000 passes, and electronic circuits to size each intercepted spot and determine its contiguity with previously intercepted spots; a count is entered into the size group interval corresponding to the largest part of the stain. The machine scans the picture 16 times, each time counting those spots larger than the present sizes (S_1, S_2, . . . , S_{16}). The net count in each group is then determined by subtraction.

b. Errors in ASCAS Procedure. A variety of potential errors associated with the determination of the droplet-size distribution by the ASCAS procedure are not discussed. One of the most obvious problems is that of overlapping stains. The machine often fails to separate contiguous stains and thus enters erroneous counts in some size groups which also may be too large (see Figure A-4). In case a (of Figure A-4), two counts, D_2 and D_m, will be recorded. In case b, only one count (D_{max}) will be entered if the scanned size-group interval length S_i is less than D_{min}; when $S_i > D_{min}$, separate counts (D_1 and D_2) will be entered.

Another problem evolves from the fact that the machine has a minimum resolving diameter D_r; any spots with diameters less than D_r will be omitted, and separated spots will sometimes be counted as one

(5) Assessment of cards exhibiting medium deposition (approximately 300 to 1000 stains) was limited to one-half of the cutout. This portion was divided into seven vertical segments (lines drawn at 0.5-centimeter intervals). Each stain in each segment was sized by category, marked and recorded.

(6) Assessment of cards exhibiting heavy deposition ($\geq$1,000 stains) was limited to one-fourth of the cutout. This portion was sectioned into seven vertical segments (with vertical lines drawn at 0.25-cm intervals). Each stain in each section was sized by category, marked and recorded.

(7) The size-count summary for all cards associated with a given trial were submitted for evaluation of the droplet spectra (see Paragraph 8.c).

8. Droplet Assessment Using ASCAS

a. Operation. The droplet stains on the collecting cards were photographed. (Unfortunately, debris or smudges on the cards were also photographed and were later indistinguishable from mixture stains. This introduced an irremediable error; all errors of the ASCAS procedure were reconciled, as will be discussed in the following paragraphs.) Sixteen size intervals (0-S_1, S_1-S_2, . . . , S_{15}-S_{16}) were selected to cover all stain diameters on the cards of the given test. A small section of the film (1 x 1 cm) was counted, and the spots were grouped into the 16 size intervals. The machine uses a "flying spot scanner," which scans the picture in approximately 1,000 passes, and electronic circuits to size each intercepted spot and determine its contiguity with previously intercepted spots; a count is entered into the size group interval corresponding to the largest part of the stain. The machine scans the picture 16 times, each time counting those spots larger than the present sizes (S_1, S_2, . . . , S_{16}). The net count in each group is then determined by subtraction.

b. Errors ' ' ASCAS Procedure. A variety of potential errors associated with the determination of the droplet-size distribution by the ASCAS procedure are not discussed. One of the most obvious problems is that of overlapping stains. The machine often fails to separate contiguous stains and thus enters erroneous counts in some size groups which also may be too large (see Figure A-4). In case a (of Figure A-4), two counts, D_2 and D_m, will be recorded. In case b, only one count (D_{max}) will be entered if the scanned size-group interval length S_i is less than D_{min}; when $S_i > D_{min}$, separate counts (D_1 and D_2) will be entered.

Another problem evolves from the fact that the machine has a minimum resolving diameter D_r; any spots with diameters less than D_r will be omitted, and separated spots will sometimes be counted as one

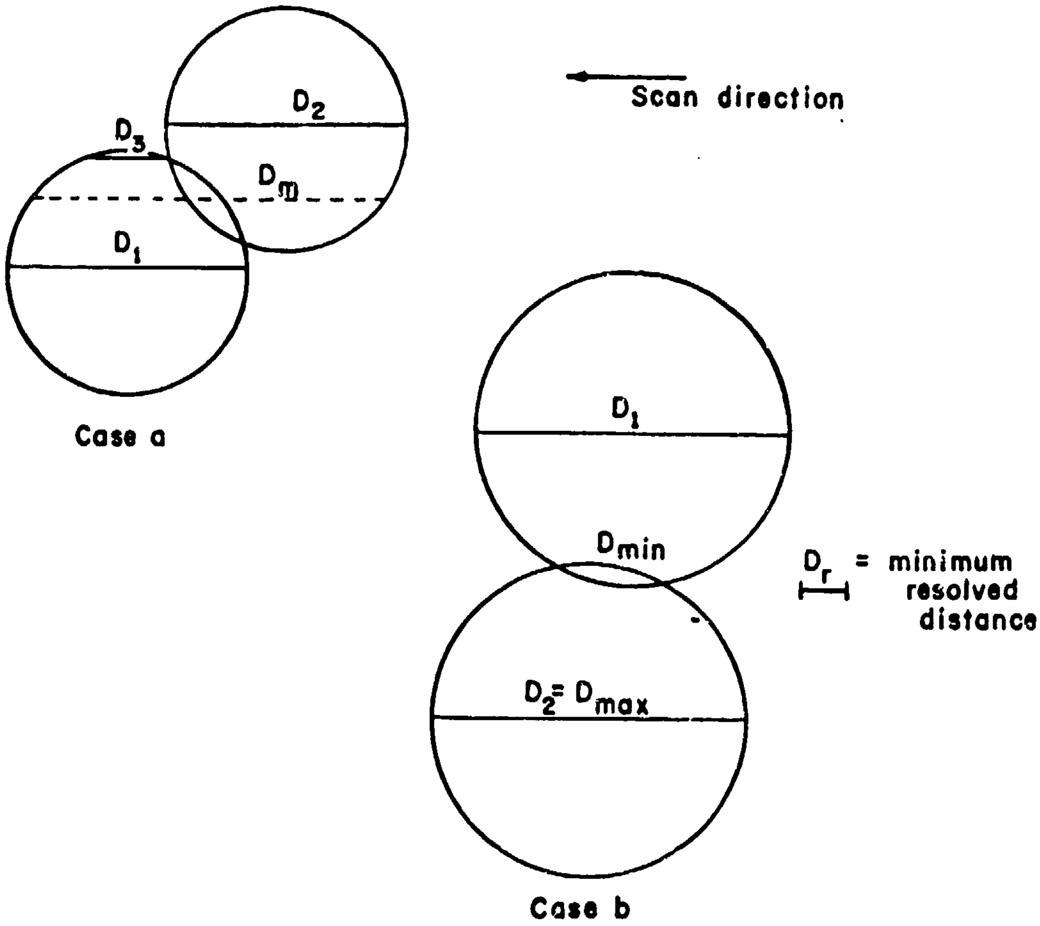


Figure A-4. Overlapping Stains

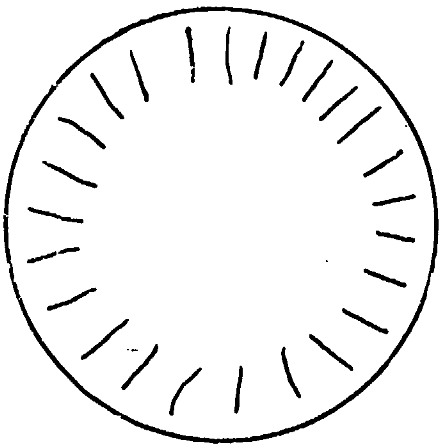


Figure A-5. Hollow Stain

spot when the separation is less than D_r.

If the center of a spot's film image is too light in color, a double count may be recorded (see Figure A-5). If the white and dark machine thresholds are not carefully set, light smudges on the collecting cards may be counted as a spot or else the borders of a blurred spot may not be determined correctly and the recorded spot diameter is too small.

c. Spectra Evaluation. The relevant definitions and numerical methods required to interpret the entries in Table A-2 are given below:

(1) Stain diameter upper limits (u) are equal to the largest diameter stains considered in the various size intervals.

(2) Droplet diameters (u) were based on the following stain-to-drop functions:

$$\text{Fuel oil drop diameter (u)} = 12.19 + 0.1221S + 1.044 \times 10^{-5}S^2$$

$$\text{Duphar drop diameter (u)} = 20.53 + 0.1193S - 0.2213 \times 10^{-5}S^2$$

where: S = stain diameter.

(3) The 16 droplet-stain diameter (u) category or interval averages were based on the expression:

$$(U^3 - L^3) / \ 3(U - L)^{1/2}$$

where: U = Upper limit of the droplet size interval

L = Lower limit of the droplet size interval

(4) Droplet masses are based on the density of the mixture as follows:

Fuel oil - 0.847 gram per milliliter

Duphar - 0.870 gram per milliliter

Two field trials (Trial 1-5 and 2-2R) were processed with the ASCAS procedure. Fuel oil No. 2 was used in both trials. The droplet spectra obtained by evaluation of ASCAS, Quantimet, and 7X magnifier data were compared (see Chapter 4). The minimum resolving diameter, D_r, for ASCAS assessment is approximately 80 microns. The results indicate that droplets in the first three categories (average drop diameters ranging in size from 16.9 to 48.7 microns) could not be adequately assessed by the ASCAS technique. Results of the droplet spectra using ASCAS input data gave overestimates of volume median diameter, number

Table A-2. Droplet Size Data for ASCAS Fuel-Oil Drop Spectra Evaluation (Trials 1-5 and 2-2R)

Size Category	Stain Diameter Upper Limit (μm)	Stain Diameter Average (μm)	Drop Diameter Average (μm)	Drop Mass Average (gm x 10^{-7})
1	68	39.3	16.9	0.021
2	204	142.0	30.6	0.127
3	341	275.8	48.7	0.514
4	477	411.4	67.4	1.359
5	613	546.9	86.4	2.859
6	749	682.6	105.7	5.235
7	885	818.4	125.3	8.723
8	1022	954.8	145.3	13.600
9	1158	1091.2	165.6	20.130
10	1294	1227.1	186.1	28.590
11	1430	1363.1	206.9	39.300
12	1566	1499.0	228.1	52.610
13	1703	1635.5	249.6	68.940
14	1839	1771.9	271.4	88.650
15	1975	1907.9	293.4	112.000
16	2111	2043.9	315.8	139.600

median diameter and deposition density for the spray system.

9. Fluorescent Particle (FP) Assessment

Rotorod samplers equipped with H and U rods were used in Trial 1-5 to sample the green fluorescent particles in the spray mixture, from the dissemination line downwind to approximately 10 miles. All rods were rotated at 2,400 revolutions per minute, which was equivalent to an aspiration or flow rate of 41.3 liters per minute. After the trial was completed, all samples were collected and the number of FP's on the collections rods were assayed in accordance with Standard Operating Procedure No. 47, Life Science Laboratory, DPG. The general procedure steps are given below:

a. A rotorod may contain one to four samples: one sample if the rotorod is rotated clockwise (CW), a second sample when rotated counter-clockwise (CCW), a third sample when the rotorod is rotated in both directions with one color, and a fourth sample when the two colors of FP are released during both rotations. The rotorod was fitted into tne plastic jig and inserted onto the mechanical stage of the microscope. The plastic jig was oriented on the stage so that the two adjacent arms of the collecting surface to be examined were parallel to the front edge of the stage. The other two adjacent collecting surfaces of the rotorod than projected out beyond the front of the microscope and faced downward.

Two types of ultraviolet (UV) lights are used when counting FP:

General Electric H100BL38-4 mercury lamps, adapted to microscope illuminator housing with condensing lenses, were used in sets of two per microscope. Two lamps were oriented and focused so that two small, narrow beams of UV light crossed immediately under the objective of the microscope and in the center of the field of vision. The room was dark for counting. When a Metronics Associates, Inc., UV light source (Model UV 85-1) was used, only one lamp per microscope was necessary, and counting was done in subdued light. These lamps were adjustable and produced a narrow beam of light that crossed the sample immediately under the objective of the microscope.

b. A monocular microscope with 100X magnification and three oculars (each containing a different size mask) was used for counting. The small mask was approximately ¼ mm wide, the medium mask approximately 1 mm wide. Each set was calibrated with a certain microscope and used only with that microscope. After each sample was completed, the microscope number and the appropriate mask size were recorded on the data sheet (Figure A-5). For the initial inspection of the sample, the 1-mm mask was used.

ROTOROD F. P. DATA SHEET																		
TEST NO					DATE COUNTED				NAME OF COUNTER						GRID			
STATION NUMBER	MICR NO	MASK SIZE			COLOR					ROTATION					AVERAGE COUNTS	TOTAL OF AVERAGES	TOTAL ARM COUNT	TOTAL
		1/4	1/2	1/4	STRIP COUNTS													

Figure A-5. Data Sheet for Rotorod Assessment of Fluorescent Particles (FP's)

When the 1-mm and ½-mm masks were used, the edges of the rotorod were within the width of the masks, but the ¼-mm mask did not contain the width of the arm. When counting a strip with the ¼-mm mask, it was necessary to start at one edge of the arm and move to the other edge, at right angles to the length of the arm. Therefore, a scanned strip always comprised a rectangle whose sides were defined by the width of the arm and the width of the mask.

c. After a preliminary scan, if it was determined there were eight or fewer particles per 1-mm-wide strip, the entire arm was counted and the total recorded in the "Arms Total" column of the data sheet. Toe total count reported for the complete sample was the sum of the counts of the four arms, and was recorded in the "Total column. When the average count per 1-mm strip was more than eight but less than 25 particles, five strips selected at random were counted on that arm and each total recorded in the "strip Count" columns. When there were 25 or more particles but less than 50 per 1-mm strip, two strips per arm were selected at random, counted, and recorded in the strip-count column. When there were 50 particles or more but less than 100 per 1-mm strip, one strip per arm was selected at random, counted, and recorded in the strip-count column. When there were more than 100 particles per 1-mm strip, the next smaller mask (½-mm) was used and the above procedure was followed, except that ½ or ¼-mm masks were never used for scanning the entire arm. When there were more than 100 particles per ½-mm mask, the next smaller mask (¼-mm) was more and with the same counting and recording procedure. The ¼-mm mask was used when the count was greater than 100 or more particles per strip.

(1) The same mask size was used for the same sample; i.e., no masks were switched in going from one arm to the other while counting the same sample.

(2) When fields were selected at random and they contained known contamination or had been scraped or otherwise altered from the original sample, another field was selected that was more representative of the original sample. When two arms were scanned and found to be negative, the entire sample was considered negative.

(3) All masks were oriented parallel to the horizontal movement of the stage.

d. After an average count for each arm was determined from the strip counts, it was recorded in the "Average Count" column. The four average counts were then added and the sum recorded in the "Total of Averages" column. The totals of averages were then multiplied by the appropriate multiplication factor (see Table A-3) and the product was recorded in the "Total" column to three significant figures. The latter value was the total estimated count for the sample corrected to a reference "flow rate" of 41.3 liters per minute.

TABLE A-3

Multiplication Factor for H Shaped Rotorods
Bio Division Microscopes 1 through 7

Rotorod Arm Length - 30 mm
Rotorod Arm Width - 0.41 mm
Reference Flowrate 41.3 liters per minute
Actual Flowrate 44.5 liters per minute at 2400 revolutions per minute.

MICROSCOPE NUMBER	NOMINAL MASK WIDTH	ACTUAL MASK WIDTH(mm)	MULTIPLICATION FACTOR
1	1	1.12	24.9
	½	0.57	48.9
	¼	0.27	103
2	1	1.10	25.3
	½	0.56	49.8
	¼	0.28	99.6
3	1	1.14	24.5
	½	0.56	49.8
	¼	0.26	107
4	1	1.12	24.9
	½	0.56	49.8
	¼	0.26	107
5	1		
	½		
	¼		
6	1	0.99	28.2
	½	0.51	54.7
	¼	0.25	112
7	1	0.95	29.3
	½	0.48	58.1
	¼	0.24	116

e. The multiplication factors given in the table applied only when the dimensions of the masks and rotorod collectors remained unchanged (and if rotorod collectors were used at 2,400 revolutions per minute). Therefore, the assessor insured that:

(1) proper mask and microscope were being used;

(2) dimensions of each production lot of rotorods were measured with calibrated equipment;

(3) correct multiplication factors were calculated and used, corresponding to the particular mask, microscope and dimension of rotorod.

For each direction of rotation and each color of FP on the rotorod, a separate total estimate was made.

Particle counts were not listed as fractions but were rounded off at the nearest particle, and totals in excess of 99 were reported in three significant figures.

For moderate to high counts, the separate average counts for each arm were within 20 percent of each other. For very low counts, agreement within 50 percent is realistic.

f. The counts obtained from the laboratory were used to characterize cloud intensity at long distances downwind (see Chapters 4 and 5).

10. <u>Droplet Assessment Using Quantimet</u>

Printflex-card samples from Trials 1-5 and 2-2R were assessed using the Quantimet 720 System, by Los Alamos Scientific Laboratory (LASL), Los Alamos, New Mexico.

a. System Description.[1] The Quantimet 720 (manufactured by IMANCO, New York) is an image-measuring device consisting of three major components (the vidicon, the detection component and the computer component). The vidicon generates the video input of the image being measured as an analogue electronic signal. The detection component assesses the features of the object under scrutiny and converts the analogue signal into digital form. The computer counts and sorts the images detected, according to the preselected stain-area categories. A number of stain-area size categories (25 categories) can be preselected to match the experimental goals. This system, when used for area-size determinations, is capable of 450 analyses in continuous operation or 600 analyses daily. The information, recorded on cassette tape, can be manipulated, reformated, or used for calculation on LASL's or other computer systems.

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[1] Letter, CMB-11, University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 24 March 1975.

b. Operation. The droplet stains on the collecting cards were measured directly from photographs. Two small sections of each card (4 square centimeters per section) were counted and for ths test, the spots grouped into 16 preselected area-size categories. The size of the section was constrained by the field of view covered by the 63-mm lens used to detect the small stains generated by the spray system in this test. Two sections were analyzed to obtain assessment of the stains encompassed by a representative 8-square-centimeter area for comparison with ASCAS and visual counting methods. The Quantimet 720 system uses a vidicon to scan each droplet stain. The scan yields the "identical stain image" transformed into an analogue electronic signal. The detection component changes the analogue signal into digital form. The "digitized" droplet stain detected is counted and sorted by a semihardwired computer. The area and perimeter of each stain detected is measured, and the total area and total perimeter are recorded for later use. (The recorded values are used as an internal quality check on the Quantimet 720 measurement).

c. Spectra Evaluation. The relevant definitions and numerical methods required to interpret the entries in Table A-2 are given below:

(1) Stain diameter upper limits (u) are equal to the largest-diameter stains considered in the various size intervals.

(2) Droplet diameters (u) were based on the following stain-to-drop functions:

$$\text{Fuel-oil drop diameter (u)} = 11.66 + 0.1322S + 0.8115 \times 10^{-5}S^2$$

$$\text{Duphar drop diameter (u)} = 12.36 + 0.1386S + 0.5883 \times 10^{-5}S^2$$

where: S = stain diameter

(3) The 16 droplet-stain diameter (u) category or interval averages were based on the expression:

$$(U^3 - L^3) / 3(U - L)^{\frac{1}{2}}$$

where: U = Upper limit of the droplet size interval

L = Lower limit of the droplet size interval

(4) Droplet masses are based on the density of the mixture as follows:

Fuel oil - 0.847 gram per milliliter

Duphar - 0.870 gram per milliliter

Two field trials (Trial 1-5 and 2-2R) were processed. Fuel oil No. 2 stained with DuPont oil red dye was used in both trials. The droplet spectra obtained by evaluation of ASCAS, Quantimet, and data were compared (see Chapter 4). In general the number of stains counted and sized for each trial by Quantimet was lower than visual assessment by approximately 25 to 50 percent. The volume median diameter (vmd) and number median diameter (nmd) obtained by Quantimet and visual methods for Trial 1-5 were comparable (within ± 2 micrometers). For Trial 2-2R, the vmd were comparable but the nmd were in variance by 8 micrometers. In both cases, the Quantimet assessment of mass was lower than visual by at least 40 percent. Results obtained from this limited data base indicate that the Quantimet 720 system can be used to rapidly obtain a valid assessment of the vmd and nmd of the overall trial but cannot assess the mass within the ground-level spray-deposition pattern. Precision is lacking because of these possible reasons: (1) the dye used in this test did not provide the expected sharp contrast between the Printflex-card background and stains deposited on the cards; (2) the range of stain sizes (more than 90 percent of the stains assessed were produced by droplets less than 70 micrometers in diameter) associated with these trials were below the optimum resolution range of the 63-mm lens; and (3) a combination of the above factors. The lower minimum resolving diameter for Quantimet is less than 20 micrometers, lower than ASCAS by a factor of 4.

The Quantimet system is being upgraded by incorporation of an improved detector component designed to reduce the errors in feature definition (errors attributable to halos around the stains) and to increase discrimination of grey levels between background and stain contrast with which may significantly improve capability of this system to assess spray droplets. A better dye system may also enhance the assessment capability of the Quantimet 720.

APPENDICES

APPENDIX B. TEST DATA

TABLE B-1. TRIAL 1-1, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	IDENTIFICATION POS	RAW DATA TABULATION: SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS): MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY: MG/M**2	OZ/ACRE
1	4	1	1	0	0	0	0	0	0	0	0	0	45.07	38.84	37.56	35.01	.02	.00
1	5	192	1600	752	832	224	144	144	64	16	0	0	101.15	64.90	42.13	50.59	103.71	14.80
1	6	132	1888	912	1392	576	288	272	176	48	48	16	117.59	76.72	53.48	55.14	251.39	35.98
1	7	176	1616	704	768	512	160	144	96	48	48	32	126.79	77.03	46.61	56.73	188.10	26.85
1	8	130	992	328	280	88	40	16	16	0	0	0	77.47	53.42	34.37	42.11	27.59	4.00
1	9	120	640	208	304	104	40	32	0	8	8	0	90.23	61.91	36.92	47.36	33.22	4.74
1	10	36	224	140	136	48	20	28	0	3	4	0	108.82	66.20	45.41	52.47	19.53	2.79
1	11	72	452	144	152	68	28	32	4	0	0	0	88.28	53.21	35.85	46.11	18.90	2.70
1	12	36	130	54	50	16	2	0	2	0	0	0	67.76	46.54	33.10	39.37	3.83	.55
1	13	24	130	72	42	20	10	4	0	0	0	0	76.56	52.19	34.71	42.08	4.93	.70
1	14	15	204	73	64	24	12	4	2	0	0	0	77.85	55.15	36.16	44.59	6.48	.92
1	15	14	222	150	90	36	18	14	0	0	0	0	90.62	58.11	41.96	47.88	10.21	1.46
1	16	11	72	29	23	8	0	0	0	0	0	0	63.37	47.58	34.94	40.66	1.47	.21
1	17	2	13	10	7	3	1	0	0	0	0	0	70.31	54.69	42.91	46.75	.56	.08
1	18	1	31	8	6	5	0	1	0	0	0	0	77.00	52.85	34.37	42.82	.73	.10
1	19	3	21	7	6	3	2	0	0	0	0	0	77.42	53.82	35.23	43.67	.63	.09
1	20	2	22	15	5	3	1	0	0	0	0	0	67.19	50.66	38.24	43.76	.61	.09
1	21	1	3	6	5	1	0	0	0	0	0	0	63.11	54.35	49.33	49.32	.25	.04
1	22	1	10	6	4	1	0	0	0	0	0	0	61.33	48.36	37.66	42.41	.24	.03
1	23	1	8	3	3	1	2	0	0	0	0	0	91.82	60.01	37.66	48.35	.37	.05
											OVERALL		107.78	67.95	42.18	51.56	11.92	1.70
2	3	68	544	156	104	64	36	4	0	0	0	0	78.23	51.92	33.79	41.63	13.06	1.36
2	4	152	1008	336	216	104	32	0	0	0	0	0	68.49	43.31	33.30	33.96	19.93	2.34
2	5	60	804	268	112	40	10	4	0	0	0	0	61.77	45.11	33.14	38.14	11.41	1.63
2	6	38	1168	424	230	40	8	0	0	0	0	0	59.78	44.63	33.39	38.38	17.05	2.44
2	7	112	1096	392	248	72	32	8	0	0	0	0	66.30	48.27	34.12	40.19	21.08	3.01
2	8	20	133	44	42	14	0	2	0	0	0	0	68.02	43.93	34.33	41.15	3.10	.44
2	9	14	106	32	26	12	4	2	0	0	0	0	74.42	51.68	34.13	41.72	2.59	.37
2	10	3	18	1	0	1	0	0	0	0	0	0	52.04	36.76	28.69	31.28	.11	.02
2	11	4	28	12	3	2	1	0	0	0	0	0	65.66	46.06	33.41	38.35	.47	.07
2	12	6	30	7	9	7	5	1	0	0	0	0	83.68	53.69	35.68	47.60	1.39	.20
2	13	5	41	12	15	3	0	0	0	0	0	0	67.11	50.37	34.76	41.37	.97	.14
2	14	8	37	22	20	5	9	4	0	0	0	0	95.17	53.12	43.23	50.35	2.52	.36
2	15	5	34	20	9	6	7	1	0	0	0	0	80.77	55.56	37.66	45.12	1.29	.18
2	16	0	1	2	0	0	1	0	0	0	0	0	98.26	67.71	46.41	55.36	.12	.02
2	17	6	56	15	15	0	1	0	0	0	0	0	66.90	48.23	33.56	40.16	1.08	.15
2	18	2	17	7	9	1	0	2	0	0	0	0	79.27	53.17	37.36	46.42	.72	.10
2	19	1	10	0	2	0	0	1	0	0	0	0	114.64	56.21	30.86	40.13	.24	.03
2	20	1	5	5	3	0	0	1	0	0	0	0	111.25	53.30	42.91	47.28	.30	.04
2	21	0	2	3	0	2	1	0	0	1	0	0	150.35	85.76	59.61	68.20	.60	.09
2	22	3	2	2	0	0	1	0	0	0	0	0	97.29	54.32	29.16	38.02	.12	.02
2	23	0	2	0	0	0	0	0	0	0	0	0	63.17	52.59	37.66	46.96	.00	.01
2	24	1	1	0	0	0	0	0	0	0	0	0	27.57	24.39	20.36	23.77	.0	.00
2	25	2	0	1	0	0	0	0	0	0	0	0	45.57	33.36	18.55	26.89	.01	.00
											OVERALL		68.37	49.25	34.02	40.76	1.37	.19

TABLE B-1. TRIAL 1-1, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
3	3	1	11	3	1	0	0	0	0	0	0	0	43.56	37.79	31.48	34.26	.02	.01
3	4	28	138	12	36	4	2	0	0	0	0	0	55.49	43.07	33.50	37.45	2.60	.37
3	5	304	2416	960	688	104	48	8	24	0	0	0	65.06	48.75	34.54	40.33	50.49	7.00
3	6	320	2592	1008	728	132	48	32	48	0	0	0	71.22	52.17	34.98	41.91	67.98	9.70
3	7	264	2030	944	440	104	48	16	0	0	0	0	62.62	46.88	34.42	39.50	38.38	5.48
3	8	260	2100	1000	600	150	30	50	30	2	0	0	72.52	52.76	35.31	42.56	59.30	8.54
3	9	256	2280	1056	336	216	128	30	40	3	3	0	85.18	56.05	37.27	45.74	92.92	13.26
3	10	64	532	244	160	76	16	12	0	0	0	0	72.33	52.50	36.25	43.33	15.29	2.18
3	11	38	242	94	56	20	2	0	0	0	0	0	62.50	45.56	34.22	39.62	4.46	.64
3	12	5	47	28	10	4	2	0	0	0	0	0	64.50	48.55	36.21	41.25	1.05	.15
3	13	2	14	7	3	1	1	0	1	0	0	0	104.71	58.26	35.23	43.75	.56	.08
3	14	3	28	12	10	2	1	0	0	0	0	0	64.55	43.35	35.34	41.96	.54	.09
3	15	4	23	8	6	4	0	0	0	0	0	0	77.52	53.66	35.07	43.39	.69	.10
3	16	9	71	29	19	5	2	0	0	0	0	0	63.94	47.70	34.37	40.35	1.40	.20
3	17	9	68	21	30	3	3	0	0	0	0	0	64.28	48.08	33.30	40.40	1.64	.23
3	18	3	17	5	2	0	1	0	1	0	0	0	129.06	56.23	32.15	39.89	.49	.07
3	19	0	8	4	2	0	0	0	0	0	0	0	53.29	53.41	35.53	33.49	.11	.02
3	20	0	6	1	2	1	0	1	0	0	0	0	111.59	65.07	35.24	50.42	.29	.04
3	21	0	7	2	8	2	0	1	0	0	0	0	75.35	54.23	57.79	54.91	.51	.07
3	22	0	0	0	2	0	0	0	0	0	0	0	64.05	34.18	64.05	64.10	.05	.01
3	23	0	1	2	0	0	0	0	0	0	0	0	45.28	42.45	42.04	41.02	.00	.00
											OVERALL		70.60	51.34	35.33	42.04	5.30	.34
											TOTAL		88.86	58.90	36.50	45.48	5.74	.82

TABLE B-2. TRIAL 1-2, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION		RAW DATA TABULATION											DIAMETERS (MICROMETERS)				DEPOSITION DENSITY	
		SIZE CATEGORIES																
ROW	POS	1	2	3	4	5	6	7	8	9	10	11	MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	NO/CM**2	OZ/ACRE
11	2	6	21	5	1	0	0	0	0	0	0	0	40.55	34.49	23.16	31.03	.12	.02
11	3	8	24	7	1	0	0	0	0	0	0	0	54.65	35.35	27.16	31.44	.13	.02
11	4	9	22	4	3	0	0	0	0	0	0	0	50.41	37.24	25.55	32.44	.17	.02
11	5	12	34	12	7	0	0	0	0	0	0	0	40.10	33.72	23.[illegible]	30.37	.22	.03
11	6	132	784	304	155	43	4	4	4	0	0	0	65.90	51.54	40.65	43.01	12.25	1.75
11	7	160	512	200	48	12	0	0	0	0	0	0	[illegible].37	40.50	31.39	34.69	4.65	.55
11	8	115	704	128	37	8	8	0	0	0	0	0	56.69	41.28	30.28	33.37	3.37	.55
11	9	300	448	354	104	16	0	4	0	0	0	0	53.37	41.97	31.97	35.01	8.74	1.75
11	10	154	272	100	32	20	8	0	0	0	0	0	65.05	52.[illegible]	36.41	33.08	4.33	.63
11	11	[illegible]	455	216	32	12	0	0	0	0	0	0	47.15	37.[illegible]	28.16	31.38	4.31	.59
11	12	104	276	124	20	4	0	0	0	0	0	0	46.23	37.51	30.52	32.90	2.65	.78
11	13	80	176	64	8	0	0	0	0	0	0	0	4[illegible].30	34.64	23.73	30.77	1.[illegible]	.19
11	14	34	153	34	16	0	0	0	0	0	0	0	4[illegible].65	36.83	28.97	30.30	1.68	.24
11	15	82	136	86	18	0	0	0	0	0	0	0	4[illegible].46	33.07	30.35	33.04	1.65	.23
11	16	50	117	46	15	4	0	0	0	0	0	0	52.32	39.16	29.61	30.98	1.36	.20
11	17	32	48	26	13	2	2	0	0	0	0	0	61.[illegible]	44.21	31.11	35.[illegible]	1.02	.15
11	18	4	3	2	1	0	0	0	0	0	0	0	53.[illegible]	35.45	26.33	31.[illegible]	.05	.01
11	19	1	1	1	0	0	0	0	0	0	0	0	43.73	35.37	29.16	31.13	.01	.00
11	20	0	1	0	0	0	0	0	0	0	0	0	29.16	29.73	29.16	29.73	.00	.00
11	21	1	1	1	0	0	0	0	0	0	0	0	43.73	35.37	29.16	31.13	.01	.00
11	22	1	1	0	0	0	0	0	0	0	0	0	27.57	24.99	20.66	23.37	.00	.00
11	23	1	4	4	1	0	0	0	0	0	0	0	49.74	42.74	37.65	38.59	.07	.01
											OVERALL		53.96	41.26	31.02	34.41	1.02	.15
22	1	7	15	6	1	0	0	0	0	0	0	0	44.54	36.49	30.29	32.74	.14	.02
22	2	11	15	5	3	0	0	0	0	0	0	0	47.80	35.57	26.90	30.14	.14	.02
22	3	5	12	8	1	0	0	0	0	0	0	0	45.60	37.91	31.99	33.32	.14	.02
22	4	7	14	4	1	0	0	0	0	0	0	0	43.44	34.56	27.95	30.03	.10	.01
22	5	5	3	6	1	0	0	0	0	0	0	0	52.15	40.11	34.33	35.74	.13	.03
22	6	12	15	9	3	0	0	0	0	0	0	0	47.14	36.82	28.60	31.52	.13	.03
22	7	24	88	38	13	8	4	2	0	0	0	0	74.53	59.11	33.60	36.93	2.13	.31
22	8	43	138	55	32	34	8	4	0	0	0	0	76.78	55.27	35.72	44.09	4.64	.59
22	9	64	220	278	100	32	8	4	0	0	0	0	63.43	50.50	41.74	43.06	8.31	1.27
22	10	368	835	632	168	32	32	0	8	0	0	0	60.43	48.84	33.98	37.54	19.60	2.80
22	11	224	492	292	88	28	0	4	0	0	0	0	55.79	42.46	31.72	35.24	8.53	1.22
22	12	124	340	130	56	12	3	4	0	0	0	0	60.25	44.58	32.56	36.57	6.13	.86
22	13	308	476	328	60	12	4	0	0	0	0	0	49.71	33.62	30.28	33.61	7.07	1.01
22	14	112	240	112	44	4	5	0	0	0	0	0	58.30	40.59	31.14	35.04	3.84	.55
22	15	156	276	88	32	16	0	0	0	0	0	0	55.54	33.22	28.55	32.27	3.28	.47
22	16	53	148	76	13	2	0	2	0	0	0	0	52.10	41.12	31.46	34.51	2.02	.29
22	17	8	16	5	3	0	2	0	0	0	0	0	33.51	47.43	23.59	35.58	.34	.05
22	18	1	5	2	1	0	0	0	0	0	0	0	51.97	40.64	32.56	35.91	.06	.01
22	19	1	2	2	1	0	0	0	0	0	0	0	55.23	44.40	37.66	33.39	.05	.01
22	20	0	3	1	0	0	0	0	0	0	0	0	39.60	35.60	31.99	33.96	.02	.00
22	21	0	0	1	0	0	0	0	0	0	0	0	46.41	46.60	46.41	46.56	.01	.00
											OVERALL		52.40	40.64	32.09	35.35	1.75	.25

TABLE B-2. TRIAL 1-2. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
33	1	1	17	4	0	0	0	0	0	0	0	0	36.70	33.48	30.16	31.57	.08	.01
33	2	6	29	9	7	1	0	0	0	0	0	0	58.52	42.92	32.39	36.94	.39	.05
33	3	4	33	12	4	0	0	0	0	0	0	0	47.64	39.08	32.25	35.20	.30	.04
33	4	3	53	7	12	4	0	0	0	0	0	0	64.23	44.59	31.41	37.11	.72	.10
33	5	7	46	17	5	0	1	0	0	0	0	0	53.64	40.82	31.38	34.93	.47	.07
33	6	22	60	27	12	8	7	1	2	0	0	0	93.76	57.26	34.12	42.76	2.49	.36
33	7	176	424	272	152	32	0	0	0	0	0	0	59.20	45.20	34.77	38.52	9.37	1.33
33	8	352	900	368	112	32	8	0	0	0	0	0	54.06	41.04	30.95	34.43	11.05	1.58
33	9	552	744	520	128	24	0	0	0	0	0	0	50.53	39.60	30.53	33.51	11.69	1.67
33	10	320	776	584	160	24	0	8	0	0	0	0	53.37	43.15	34.16	36.83	14.33	2.05
33	11	16	122	36	16	4	0	0	0	0	0	0	55.22	41.41	32.09	36.03	1.33	.19
33	12	13	55	18	4	1	0	0	0	0	0	0	46.90	37.89	30.71	33.35	.47	.07
33	13	7	43	8	2	0	0	0	0	0	0	0	39.56	34.70	29.75	31.65	.24	.03
33	14	10	3	4	5	0	0	0	0	0	0	0	59.40	41.59	28.22	33.76	.19	.03
33	15	7	14	7	5	0	0	0	0	0	0	0	56.57	41.95	32.20	35.34	.23	.03
33	16	7	3	4	2	0	0	0	0	0	0	0	52.54	33.30	28.10	31.09	.11	.02
33	17	1	3	0	0	0	0	0	0	0	0	0	28.63	27.56	26.33	26.55	.01	.00
33	18	0	1	2	0	0	0	0	0	0	0	0	45.28	42.45	42.04	41.02	.02	.00
33	19	0	0	0	0	1	0	0	0	0	0	0	82.02	82.09	82.02	82.09	.05	.01
33	20	1	0	0	0	0	0	0	0	0	0	0	16.43	17.00	16.43	17.00	.00	.00
33	23	0	0	1	0	0	0	0	0	0	0	0	46.41	46.66	46.41	46.66	.01	.00
											OVERALL		54.73	42.23	32.21	35.56	1.05	.15
											TOTAL		55.74	42.47	31.76	35.28	1.25	.18

TABLE B-3. TRIAL 1-3, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	PCE	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
1	1	72	224	276	44	4	4	0	0	0	0	0	50.05	43.73	33.67	33.37	4.93	.71
1	2	304	720	736	120	48	16	0	0	0	0	0	52.74	44.36	36.43	38.15	16.22	2.32
1	3	238	556	544	38	32	24	0	0	0	0	0	53.80	44.02	34.34	37.05	13.31	1.90
1	4	536	1432	1416	448	160	56	24	0	0	0	0	64.13	45.31	38.50	41.39	46.69	6.66
1	5	640	1152	396	240	64	48	32	0	0	0	0	65.96	47.34	33.88	37.83	31.17	4.45
1	6	304	1152	1100	352	80	32	32	0	0	0	0	62.64	49.36	33.91	41.62	35.32	5.04
1	7	512	1104	1136	432	80	32	16	0	0	0	0	61.03	43.25	38.65	40.78	36.10	5.15
1	8	320	1248	1328	416	144	48	0	0	0	0	0	60.74	48.21	40.09	42.20	38.97	5.56
1	9	200	400	320	53	28	12	0	0	0	0	0	55.96	44.34	34.01	37.05	3.57	1.22
1	10	74	154	128	12	5	0	0	0	0	0	0	47.61	39.98	33.13	34.95	2.29	.33
1	11	74	130	142	32	6	0	0	0	0	0	0	50.47	41.62	34.17	36.36	2.39	.43
1	12	50	168	120	22	8	2	2	0	0	0	0	54.30	44.37	34.42	37.51	3.11	.44
1	13	86	176	150	32	6	0	0	0	0	0	0	49.93	41.23	33.99	35.96	3.02	.43
1	14	42	136	118	32	6	0	0	0	0	0	0	53.35	44.30	36.28	38.57	2.75	.40
1	15	42	104	84	36	0	0	0	0	0	0	0	53.16	42.93	35.53	37.73	2.01	.29
1	16	32	52	50	28	2	0	0	0	0	0	0	55.89	46.91	37.33	39.67	1.64	.23
1	17	19	34	24	4	1	0	0	0	0	0	0	48.65	33.45	31.66	34.36	.48	.07
1	18	13	27	16	0	1	0	0	0	0	0	0	45.23	37.28	30.42	32.50	.22	.04
1	19	8	23	12	1	0	0	0	0	0	0	0	43.69	36.43	31.01	32.82	.20	.03
1	20	7	22	11	1	1	0	0	0	0	0	0	48.02	39.29	31.46	34.11	.24	.03
1	21	5	8	2	1	0	0	0	0	0	0	0	47.69	35.28	27.04	30.02	.07	.01
1	22	7	15	5	1	0	0	0	0	0	0	0	43.58	35.00	28.60	30.80	.11	.02
1	23	6	17	4	0	0	0	0	0	0	0	0	36.33	31.38	23.16	23.41	.09	.01
											OVERALL		59.21	46.66	36.53	39.29	4.25	.01
2	1	78	190	144	13	0	2	0	0	0	0	0	47.26	39.53	37.01	34.34	2.55	.37
2	2	58	172	104	26	2	2	0	0	0	0	0	50.72	41.16	32.92	35.08	2.43	.35
2	3	94	218	144	38	6	2	0	0	0	0	0	51.92	41.63	32.80	35.72	3.46	.49
2	4	360	1500	1616	720	240	36	16	0	0	0	0	66.29	51.35	40.52	43.01	62.76	8.36
2	5	360	2704	2672	1168	128	112	32	0	0	0	0	60.92	48.53	39.13	41.40	85.51	12.21
2	6	360	1128	1040	312	30	32	8	8	0	0	0	61.25	47.20	36.15	39.03	31.93	4.56
2	8	108	500	140	112	8	0	0	0	0	0	0	57.25	41.55	31.31	35.94	5.02	.36
2	10	30	556	34	50	0	0	4	0	0	0	0	53.14	38.67	30.14	33.18	4.31	.62
2	11	38	226	68	40	0	0	0	0	0	0	0	59.13	43.27	32.09	36.51	2.94	.42
2	12	92	232	138	23	6	0	2	0	0	0	0	49.26	41.70	34.00	36.06	3.80	.54
2	13	110	236	220	57	16	4	0	0	0	0	0	53.57	44.31	35.00	37.39	5.33	.77
2	14	44	352	178	34	16	6	0	0	0	0	0	58.00	42.94	32.06	36.24	4.24	.61
2	15	24	300	90	56	10	14	0	0	0	0	0	65.53	47.11	33.30	39.17	4.94	.71
2	16	24	134	40	25	6	0	0	0	0	0	0	56.25	40.65	31.26	35.19	1.86	.27
2	17	11	58	9	7	2	0	0	0	0	0	0	49.43	37.54	29.50	32.39	.42	.06
2	18	13	23	13	4	3	0	0	0	0	0	0	61.23	43.80	31.75	35.97	.45	.06
2	19	5	22	9	4	0	0	0	0	0	0	0	50.77	43.08	32.25	35.33	.25	.04
2	20	5	10	3	2	0	0	0	0	0	0	0	53.35	33.27	29.16	32.73	.11	.02
2	21	6	18	5	0	0	0	0	0	0	0	0	37.75	32.06	28.59	30.02	.10	.01
2	22	10	14	3	0	0	0	0	0	0	0	0	35.06	29.90	24.91	26.90	.07	.01
2	23	6	17	4	1	0	0	0	0	0	0	0	41.35	34.47	23.96	30.65	.11	.02

TABLE B-3. TRIAL 1-3. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
2	24	5	15	2	1	0	0	0	0	0	0	0	39.55	33.36	27.46	29.40	.09	.01
2	25	6	11	4	0	0	0	0	0	0	0	0	39.55	32.56	27.62	29.32	.07	.01
2	26	3	8	2	0	0	0	0	0	0	0	0	36.78	32.06	28.10	29.40	.04	.01
2	27	2	5	2	0	0	0	0	0	0	0	0	40.33	33.70	29.16	30.67	.03	.00
2	28	3	6	3	0	0	0	0	0	0	0	0	41.46	34.13	29.16	30.78	.05	.01
2	29	4	6	1	0	0	0	0	0	0	0	0	33.58	29.38	24.91	26.64	.03	.00
2	30	1	5	0	0	0	0	0	0	0	0	0	28.84	28.32	27.46	27.61	.01	.00
2	31	4	5	2	0	0	0	0	0	0	0	0	39.90	31.82	25.76	28.18	.03	.00
2	32	2	3	1	0	0	0	0	0	0	0	0	38.77	31.65	26.33	28.31	.02	.00
2	33	1	3	0	0	0	0	0	0	0	0	0	28.63	27.56	26.33	26.55	.01	.00
2	34	1	0	0	0	0	0	0	0	0	0	0	16.43	17.00	16.43	17.00	.00	.00
											OVERALL		60.37	46.39	34.72	38.68	1.23	.18
3	1	52	168	70	32	5	2	0	0	0	0	0	57.26	42.68	32.15	36.12	2.66	.38
3	2	64	158	110	40	2	2	0	0	0	0	0	53.45	42.43	33.71	36.65	2.33	.40
3	3	90	165	122	24	10	2	0	0	0	0	0	52.84	42.19	32.64	35.56	2.97	.42
3	4	48	156	92	28	4	4	0	0	0	0	0	55.10	43.45	33.46	36.93	2.62	.37
3	5	72	214	122	42	3	2	0	0	0	0	0	54.53	42.75	33.21	36.59	2.44	.43
3	6	100	324	168	36	16	8	0	0	0	0	0	55.53	43.19	32.52	36.20	5.02	.72
3	7	392	912	936	360	112	48	16	0	0	0	0	65.60	50.32	39.23	41.96	33.82	4.83
3	8	392	1968	2576	1088	368	224	0	0	0	0	0	67.51	52.77	42.36	44.08	99.09	14.14
3	9	456	1332	1596	758	224	48	0	0	0	0	0	62.36	50.37	42.20	43.75	56.10	8.01
3	10	256	1056	1088	336	96	32	0	0	0	0	0	53.65	47.85	33.59	41.61	30.01	4.28
3	11	176	560	720	288	96	32	0	0	0	0	0	63.56	51.14	42.52	44.24	23.94	7.42
3	12	136	464	424	200	72	0	0	0	0	0	0	61.35	48.59	39.54	42.16	14.21	2.03
3	13	130	416	250	56	12	4	0	0	0	0	0	52.31	40.49	31.54	34.26	5.51	.79
3	14	76	196	110	40	12	0	0	0	0	0	0	55.10	42.81	33.15	36.56	3.30	.47
3	15	64	226	108	36	12	0	0	0	0	0	0	54.52	42.35	32.78	36.34	3.17	.45
3	16	42	142	84	35	4	2	0	0	0	0	0	56.77	44.10	34.31	37.30	2.55	.37
3	17	45	66	30	10	1	0	0	0	0	0	0	50.70	38.60	29.42	32.69	.90	.13
3	18	14	25	13	5	1	0	0	0	0	0	0	55.59	41.40	31.20	34.33	.40	.06
3	19	8	27	7	2	0	0	0	0	0	0	0	43.70	35.62	29.48	31.68	.19	.03
3	20	5	15	6	0	0	0	0	0	0	0	0	40.33	33.70	29.16	30.57	.10	.01
3	21	9	15	7	0	0	0	0	0	0	0	0	41.02	33.35	28.03	29.96	.11	.02
3	22	8	13	5	0	0	0	0	0	0	0	0	39.85	32.46	27.20	29.07	.03	.01
3	23	5	12	5	0	0	0	0	0	0	0	0	40.55	33.78	29.16	30.69	.08	.01
											OVERALL		62.17	48.34	37.99	40.92	5.05	.72
											TOTAL		60.75	47.09	36.34	39.57	2.53	.36

TABLE B-4. TRIAL 1-4, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
11	1	4	17	3	3	0	0	0	0	0	0	0	60.31	44.85	32.66	33.34	.23	.04
11	2	10	180	38	30	4	4	0	0	0	0	0	62.31	45.37	32.77	38.32	2.29	.33
11	3	24	200	64	34	16	4	0	0	0	0	0	68.33	45.34	31.38	37.38	2.73	.40
11	4	8	358	80	76	24	0	0	0	0	0	0	62.16	45.40	33.27	39.16	4.87	.69
11	5	40	656	178	224	56	8	4	0	0	0	0	65.63	49.41	34.71	41.90	13.47	1.32
11	6	20	682	228	216	40	16	6	0	0	0	0	65.69	49.81	35.19	43.08	14.37	2.05
11	7	28	500	175	380	90	0	15	0	0	0	0	69.63	55.11	39.51	46.72	17.50	2.50
11	8	10	46	30	30	6	0	0	0	0	0	0	62.36	48.36	36.37	41.90	1.54	.22
11	9	4	102	42	24	2	0	0	0	0	0	0	55.35	43.60	34.49	33.38	1.33	.20
11	10	3	82	16	20	4	0	0	0	0	0	0	61.35	44.32	42.46	37.94	1.08	.15
11	11	5	76	28	13	4	2	0	0	0	0	0	62.87	46.35	34.31	39.35	1.33	.19
11	12	4	78	22	24	4	0	0	0	0	0	0	68.63	51.01	34.61	42.07	1.75	.25
11	13	4	30	6	40	2	0	0	0	0	0	0	64.33	43.69	34.05	42.23	1.57	.22
11	14	4	72	14	18	2	2	0	0	0	0	0	63.38	45.86	32.65	38.65	1.09	.16
11	15	4	64	26	12	2	0	0	0	0	0	0	54.36	43.06	33.34	38.13	.82	.12
11	16	5	68	14	3	0	0	0	0	0	0	0	48.25	38.21	31.16	34.28	.51	.07
11	17	2	102	12	16	2	2	0	0	0	0	0	62.42	43.50	31.66	36.30	1.08	.15
11	18	14	54	24	18	2	0	0	0	0	0	0	58.13	43.83	33.57	37.77	.89	.13
11	19	3	64	18	14	2	0	0	0	0	0	0	59.35	43.43	32.61	37.51	.87	.12
11	20	2	40	6	12	0	0	0	0	0	0	0	59.23	42.90	32.40	37.63	.47	.07
11	21	3	18	5	8	0	0	0	0	0	0	0	58.66	42.28	32.09	36.89	.33	.05
11	22	0	20	6	2	0	0	0	0	0	0	0	46.46	39.02	32.56	35.82	.16	.02
11	23	0	7	2	1	0	0	0	0	0	0	0	49.88	40.24	32.30	36.56	.06	.01
											OVERALL		63.45	47.08	33.78	39.93	1.43	.20
22	1	7	22	11	5	0	2	0	0	0	0	0	59.23	44.54	33.02	37.12	.39	.06
22	2	64	228	112	44	0	0	0	0	0	0	0	50.44	39.70	31.85	34.74	2.81	.40
22	3	55	300	136	32	8	3	0	0	0	0	0	54.54	43.01	32.79	36.54	4.11	.59
22	4	136	460	244	76	4	6	0	0	0	0	0	52.65	41.84	32.78	35.37	6.50	.93
22	5	203	852	436	140	24	8	8	0	0	0	0	56.18	43.67	33.23	36.35	13.35	1.91
22	6	152	568	284	188	26	12	8	0	0	0	0	62.96	46.87	33.84	38.97	13.20	1.88
22	7	44	135	50	22	6	2	2	0	0	0	0	63.33	44.71	31.54	36.14	2.24	.32
22	8	18	34	28	14	0	0	0	0	0	0	0	50.20	38.83	31.15	34.29	.85	.12
22	9	22	112	40	3	2	2	0	0	0	0	0	51.14	40.51	31.44	34.67	1.19	.17
22	10	18	104	46	6	0	0	0	0	0	0	0	46.17	38.68	32.10	34.62	.97	.14
22	11	32	112	40	15	2	2	0	0	0	0	0	55.56	41.45	31.29	34.96	1.39	.20
22	12	36	132	70	16	0	0	0	0	0	0	0	47.12	38.84	32.25	34.62	1.43	.20
22	13	23	103	54	22	4	0	0	0	0	0	0	54.48	42.42	33.25	36.79	1.53	.23
22	14	30	122	40	22	2	0	0	0	0	0	0	53.68	40.22	31.25	34.71	1.39	.20
22	15	24	128	40	18	2	0	0	0	0	0	0	51.55	39.35	31.55	34.30	1.29	.18
22	16	14	76	34	10	0	0	0	0	0	0	0	47.86	39.35	32.52	35.27	.78	.11
22	17	16	60	34	10	0	0	0	0	0	0	0	47.59	33.96	32.14	34.35	.73	.11
22	18	19	75	24	3	1	0	0	0	0	0	0	43.83	36.33	30.18	32.36	.55	.08
22	19	13	45	7	5	0	0	0	0	0	0	0	49.13	36.22	23.32	31.46	.35	.05
22	20	5	24	10	2	0	0	0	0	0	0	0	45.28	37.44	31.29	33.58	.21	.03
22	21	3	8	5	2	0	0	0	0	0	0	0	51.65	41.23	33.41	36.14	.17	.02

TABLE B-4. TRIAL 1-4, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION		RAW DATA TABULATION											DIAMETERS (MICROMETERS)				DEPOSITION DENSITY	
		SIZE CATEGORIES																
ROW	POS	1	2	3	4	5	6	7	8	9	10	11	MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	MC/M**2	OZ/ACRE
22	22	2	6	3	0	0	0	0	0	0	0	0	41.60	35.02	30.58	32.03	.05	.01
22	23	0	1	0	0	0	0	0	0	0	0	0	29.16	29.73	29.16	29.73	.00	.00
											OVERALL		53.63	41.62	32.20	35.66	1.11	.16
33	1	100	340	28	9	2	1	0	0	0	0	0	35.19	30.92	25.04	26.91	1.65	.24
33	2	7	19	15	3	5	0	0	0	0	0	0	67.03	50.46	38.83	42.74	.66	.09
33	3	9	19	15	8	0	0	0	0	0	0	0	55.37	43.45	35.42	37.37	.40	.06
33	4	22	58	24	24	4	0	0	0	0	0	0	61.45	45.74	33.56	38.54	1.21	.17
33	5	160	516	444	252	36	32	0	0	0	0	0	63.10	49.85	39.39	42.45	17.06	2.43
33	6	160	600	5 0	268	40	28	6	0	0	0	0	63.38	50.10	39.41	42.53	19.53	2.79
33	7	7	46	33	10	3	1	0	0	0	0	0	57.59	46.28	36.55	40.15	.95	.14
33	8	15	50	25	12	2	0	0	0	0	0	0	56.15	42.89	33.24	36.95	.78	.11
33	9	6	43	28	7	1	1	0	0	0	0	0	53.36	44.19	35.29	38.59	.71	.10
33	10	18	65	45	11	2	1	0	0	0	0	0	52.60	43.13	34.52	37.39	1.09	.16
33	11	14	53	30	14	4	0	0	0	0	0	0	58.54	44.92	34.61	38.61	1.00	.14
33	12	16	71	44	12	1	0	0	0	0	0	0	53.87	43.68	34.31	37.60	1.16	.17
33	13	20	114	52	14	4	0	0	0	0	0	0	51.03	41.22	32.89	36.19	1.37	.20
33	14	22	114	66	14	0	0	0	0	0	0	0	47.19	39.70	33.45	35.84	1.29	.18
33	15	20	112	72	22	0	0	0	0	0	0	0	49.74	41.52	34.78	37.35	1.55	.22
33	16	18	72	48	15	4	0	0	0	0	0	0	54.43	43.83	35.06	38.24	1.27	.18
33	17	14	45	24	24	4	0	0	0	0	0	0	64.71	43.83	36.24	41.35	1.37	.20
33	18	22	82	38	15	0	0	0	0	0	0	0	50.67	40.32	32.48	35.52	.99	.14
33	19	14	62	38	10	0	0	0	0	0	0	0	48.56	40.44	33.82	36.26	.78	.11
33	20	3	21	14	5	0	0	0	0	0	0	0	51.06	42.54	35.84	38.36	.32	.05
33	21	2	8	6	0	0	0	0	0	0	0	0	50.85	42.26	35.53	37.73	.13	.02
33	22	1	12	5	1	0	0	0	0	0	0	0	45.45	38.90	32.70	35.33	.10	.01
33	23	1	5	3	1	0	0	0	0	0	0	0	50.09	41.32	34.26	36.98	.07	.01
											OVERALL		58.09	45.13	34.89	38.59	1.27	.18
											TOTAL		59.28	44.61	33.49	37.97	1.27	.18

TABLE B-5. TRIAL 1-5. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	KA DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
1	8	128	696	208	175	32	8	4	0	0	0	0	52.02	45.66	32.32	38.15	11.39	1.63
1	9	128	960	232	208	40	11	0	0	0	0	0	61.69	44.56	32.45	37.69	12.21	1.89
1	10	200	900	224	132	36	4	0	0	0	0	0	57.33	41.43	31.05	35.08	10.20	1.46
1	11	40	460	128	128	24	5	0	0	0	0	0	61.96	43.02	33.57	39.43	7.31	1.04
1	12	16	220	50	30	2	2	0	0	0	0	0	55.31	40.57	31.79	35.74	2.10	.30
1	13	0	56	24	14	0	0	0	0	0	0	0	54.20	42.76	34.44	38.54	.77	.10
1	14	2	64	32	16	0	0	0	0	0	0	0	53.25	43.17	35.27	39.10	.88	.13
1	15	6	60	16	19	0	0	0	0	0	0	0	57.64	43.15	33.41	38.05	.73	.11
1	16	20	136	32	20	2	0	0	0	0	0	0	49.47	37.93	30.55	33.61	1.47	.20
1	17	6	50	12	10	0	0	0	0	0	0	0	55.45	40.57	31.88	35.77	.50	.07
1	18	0	17	19	1	1	0	0	0	0	0	0	48.10	43.81	39.50	40.48	.31	.04
1	19	0	7	1	1	0	0	0	0	0	0	0	52.07	36.10	27.95	30.83	.05	.01
1	20	1	2	1	0	0	0	0	0	0	0	0	41.46	34.13	29.16	30.78	.02	.00
1	21	0	1	1	0	0	0	0	0	0	0	0	44.15	35.99	37.66	38.20	.01	.00
1	22	1	1	0	1	0	0	0	0	0	0	0	63.01	46.13	29.16	36.97	.03	.00
1	23	0	1	2	1	0	0	0	0	0	0	0	56.34	49.79	46.41	46.81	.05	.01
											OVERALL		58.77	42.82	33.14	36.65	1.03	.15
2	8	116	252	126	59	16	5	2	0	0	0	0	53.22	45.79	32.60	37.31	5.38	.77
2	9	144	544	296	144	28	4	0	0	0	0	0	58.09	44.57	34.29	38.26	9.82	1.40
2	10	309	904	416	200	24	10	0	0	0	0	0	56.93	42.77	32.40	36.23	13.94	1.99
2	11	243	556	219	32	8	4	0	0	0	0	0	52.13	39.11	30.09	33.30	7.00	1.00
2	12	48	128	58	32	2	0	0	0	0	0	0	57.37	40.74	32.22	36.10	2.02	.29
2	13	40	92	30	23	2	0	0	0	0	0	0	56.17	41.56	30.82	34.99	1.30	.19
2	14	34	134	65	40	4	4	0	0	0	0	0	60.75	45.87	34.11	38.75	2.58	.37
2	15	73	260	232	75	0	0	0	0	0	0	0	61.20	42.91	36.74	38.39	4.66	.69
2	16	18	68	40	18	0	0	0	0	0	0	0	52.33	42.11	34.41	37.29	1.04	.15
2	17	5	15	7	7	0	0	0	0	0	0	0	58.63	44.42	34.26	36.44	.29	.04
2	18	16	34	15	9	1	1	0	0	0	0	0	60.56	43.92	31.66	36.09	.67	.09
2	19	4	24	9	5	1	0	0	0	0	0	0	57.29	43.03	33.06	37.31	.37	.05
2	20	2	11	2	4	0	0	0	0	0	0	0	53.84	43.46	32.25	37.43	.15	.02
2	21	1	7	6	2	0	0	0	0	0	0	0	51.30	43.31	37.06	39.59	.13	.02
2	22	4	11	7	6	0	0	0	0	0	0	0	58.34	45.32	36.11	39.53	.25	.04
2	23	0	4	2	2	0	0	0	0	0	0	0	56.27	47.12	37.66	42.58	.08	.01
2	24	1	6	0	2	0	0	0	0	0	0	0	61.32	42.51	30.58	35.97	.07	.01
2	25	0	5	2	1	0	0	0	0	0	0	0	52.14	42.15	34.06	38.27	.06	.01
2	26	0	3	1	0	0	0	0	0	0	0	0	39.62	35.60	31.39	33.96	.02	.00
2	27	0	5	4	1	0	0	0	0	0	0	0	49.26	43.13	37.66	39.95	.08	.01
2	28	2	8	2	2	0	0	0	0	0	0	0	56.94	40.82	31.29	35.25	.09	.01
2	29	2	4	5	3	0	0	0	0	0	0	0	57.08	46.59	41.16	41.34	.14	.02
2	30	3	3	4	3	0	0	0	0	0	0	0	56.69	42.42	32.94	36.73	.14	.02
2	31	4	10	5	6	0	0	0	0	0	0	0	59.63	45.64	35.11	39.35	.23	.03
2	32	2	8	7	3	0	0	0	0	0	0	0	53.47	44.13	37.60	39.55	.10	.02
2	33	4	8	5	4	0	0	0	0	0	0	0	57.96	44.05	34.47	37.90	.17	.02
2	34	1	14	10	3	0	0	0	0	0	0	0	50.04	42.71	36.45	39.01	.21	.03
2	35	3	10	8	2	0	0	0	0	0	0	0	49.12	41.39	35.11	36.98	.15	.02

TABLE B-5. TRIAL 1-5. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
2	36	4	13	7	2	0	0	0	0	0	0	0	48.48	39.49	32.43	34.98	.15	.02
2	37	2	12	5	2	1	0	0	0	0	0	0	59.35	44.32	33.41	37.93	.16	.03
2	38	3	21	4	3	0	0	0	0	0	0	0	51.29	38.48	30.78	34.02	.17	.02
2	39	1	7	6	4	0	0	0	0	0	0	0	57.35	46.69	40.58	42.32	.18	.03
2	40	2	11	6	8	1	0	0	0	0	0	0	62.76	43.94	37.56	42.52	.29	.04
2	41	2	8	4	2	0	0	0	0	0	0	0	53.06	41.64	33.41	36.68	.11	.02
2	42	0	12	3	3	0	0	0	0	0	0	0	57.11	42.92	33.41	38.30	.14	.02
2	43	1	7	5	2	0	0	0	0	0	0	0	52.27	43.39	36.45	39.12	.12	.02
2	44	2	5	4	0	0	0	0	0	0	0	0	43.58	39.10	35.96	37.26	.05	.01
2	45	3	3	4	1	0	0	0	0	0	0	0	50.09	41.11	34.83	35.55	.07	.01
2	46	3	4	2	1	0	0	0	0	0	0	0	50.57	39.71	31.29	34.01	.07	.01
2	47	0	9	4	2	0	0	0	0	0	0	0	41.32	36.71	32.94	34.94	.06	.01
2	48	2	4	5	2	0	0	0	0	0	0	0	53.55	44.58	39.41	39.58	.11	.02
2	49	1	6	2	2	0	0	0	0	0	0	0	57.91	43.33	33.41	37.92	.09	.01
2	50	2	8	3	1	0	0	0	0	0	0	0	49.20	39.45	31.99	34.71	.07	.01
2	51	0	4	4	2	0	0	0	0	0	0	0	55.46	47.03	42.04	43.39	.10	.01
2	52	1	5	3	1	0	0	0	0	0	0	0	50.09	41.32	34.26	36.98	.07	.01
2	53	3	9	4	0	0	0	0	0	0	0	0	41.00	34.51	30.11	31.58	.06	.01
2	54	8	9	7	0	0	0	0	0	0	0	0	43.14	35.41	30.11	31.65	.09	.01
2	55	3	11	6	1	0	0	0	0	0	0	0	45.85	38.28	32.25	34.39	.11	.02
2	56	5	6	4	7	0	0	0	0	0	0	0	48.16	37.64	29.16	32.14	.08	.01
2	57	3	6	5	1	0	0	0	0	0	0	0	48.00	39.79	33.41	35.13	.09	.01
2	58	3	5	3	0	0	0	0	0	0	0	0	42.22	34.48	29.16	30.38	.04	.01
2	59	4	5	3	3	0	0	0	0	0	0	0	58.95	43.67	32.59	36.61	.12	.02
											OVERALL		54.50	42.57	33.50	36.34	.24	.03
3	9	300	564	458	232	44	4	4	0	0	0	0	59.22	45.64	35.20	38.55	15.78	2.25
3	10	460	532	656	352	16	8	8	4	0	0	0	58.67	45.39	34.95	38.05	22.14	3.16
3	11	348	1129	643	260	36	12	0	0	0	0	0	55.65	43.36	33.76	37.24	18.92	2.70
3	12	128	592	480	188	16	4	0	0	0	0	0	54.19	43.31	34.81	37.70	12.50	1.78
3	13	138	622	382	116	12	0	0	0	0	0	0	51.33	41.23	33.16	36.09	8.63	1.23
3	14	148	524	260	104	24	8	0	0	0	0	0	57.08	43.85	33.51	37.32	8.73	1.25
3	15	52	419	116	79	12	0	0	0	0	0	0	56.83	41.98	32.27	36.50	4.75	.68
3	16	6	56	12	12	0	0	0	0	0	0	0	56.44	40.92	31.99	36.01	.56	.08
3	17	10	35	22	22	0	0	0	0	0	0	0	57.03	41.86	32.44	36.30	1.00	.14
3	19	1	5	5	1	0	0	0	0	0	0	0	48.62	42.31	37.66	38.60	.09	.01
3	20	1	4	2	1	0	0	0	0	0	0	0	53.06	41.64	33.41	36.68	.06	.01
3	21	1	11	2	4	1	0	0	0	0	0	0	64.52	48.05	33.80	40.35	.20	.03
3	22	2	2	1	3	1	0	0	0	0	0	0	68.41	55.16	46.41	46.08	.14	.02
3	23	2	5	5	3	0	0	0	0	0	0	0	53.09	43.82	37.66	38.88	.11	.02
											OVERALL		56.77	43.52	33.59	37.41	2.27	.32
											TOTAL		56.26	43.00	33.27	37.05	.47	.07

TABLE B-6. TRIAL 1-5. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MC/M**2	OZ/ACRE
1	6	272	664	900	772	200	104	68	30	12	0	0	82.46	62.95	43.94	51.84	72.32	10.32
1	7	400	872	1136	1056	464	176	80	24	16	8	0	84.32	64.97	50.67	53.42	111.00	15.84
1	8	416	688	1008	816	240	144	48	16	16	0	0	81.60	61.36	47.94	50.57	76.80	10.96
1	9	248	416	536	392	176	56	0	8	0	0	0	73.40	57.34	45.89	48.00	33.03	4.71
1	10	136	316	332	316	56	24	16	0	0	0	0	68.27	55.27	45.36	47.15	19.94	2.35
1	11	64	568	244	260	76	24	20	4	3	0	0	79.58	57.02	36.44	45.23	24.25	3.46
1	12	44	408	120	100	64	24	28	0	0	0	0	87.67	58.35	35.24	45.55	14.97	2.14
1	13	108	288	328	144	20	16	12	4	0	0	0	67.95	53.08	41.08	43.57	13.16	1.88
1	14	56	212	264	92	40	38	12	4	0	0	0	82.92	58.02	43.36	47.40	13.23	1.89
1	15	80	208	196	80	44	12	8	0	0	0	0	76.06	53.22	39.09	43.27	8.76	1.25
1	16	48	216	196	144	56	20	4	0	0	0	0	71.56	56.27	44.63	47.82	11.65	1.65
1	17	20	206	76	88	24	3	4	0	2	0	0	72.75	55.77	36.67	44.92	6.53	.99
1	18	30	230	72	77	22	0	4	0	0	0	0	56.66	43.19	34.26	40.85	4.87	.70
1	20	34	150	86	36	10	4	0	0	0	0	0	61.00	46.39	34.94	39.32	3.05	.44
1	21	26	118	72	36	12	0	0	0	0	0	0	60.41	46.59	35.93	40.17	2.55	.36
1	22	32	104	86	18	10	2	0	0	0	0	0	56.45	45.63	36.03	38.99	2.29	.33
1	23	24	126	24	20	4	0	0	0	0	0	0	51.13	42.52	34.96	37.75	1.91	.27
											OVERALL		74.58	56.43	41.75	46.17	11.11	1.59
2	3	0	4	2	0	0	0	0	0	0	0	0	41.82	37.16	33.41	35.38	.03	.00
2	4	1	6	1	3	0	0	0	0	0	0	0	61.09	45.81	33.41	39.51	.10	.01
2	5	0	6	3	2	1	0	0	0	0	0	0	65.58	50.49	37.66	44.07	.15	.02
2	6	0	4	3	4	0	0	0	0	0	0	0	60.51	51.10	46.41	46.88	.14	.02
2	7	128	752	768	448	224	160	48	0	0	16	0	90.52	64.22	46.60	51.96	64.42	9.19
2	8	304	912	720	496	160	64	32	32	0	0	0	73.32	57.67	41.16	46.14	49.89	7.12
2	9	240	1344	848	464	112	48	80	16	16	0	0	68.42	57.31	37.66	44.72	57.02	8.14
2	10	184	696	624	312	120	72	16	0	24	0	0	86.02	59.24	41.70	46.75	40.71	5.81
2	11	136	632	400	272	40	32	0	8	3	0	0	70.14	53.73	37.55	43.25	22.66	3.23
2	12	52	456	340	128	60	20	8	4	0	0	4	80.59	56.09	39.10	44.55	18.09	2.58
2	13	72	356	268	152	32	20	12	0	0	0	0	68.76	52.94	39.49	44.01	12.94	1.85
2	14	48	300	276	160	24	8	2	2	0	0	0	64.90	52.37	41.73	44.66	11.34	1.62
2	15	44	260	164	140	20	24	0	0	4	0	0	70.63	55.45	40.22	45.43	10.69	1.53
2	16	22	136	80	54	22	10	2	0	0	0	0	80.04	57.08	39.58	46.32	5.94	.85
2	17	24	140	66	42	14	4	2	2	0	0	0	72.02	52.30	35.60	42.22	4.02	.57
2	18	30	122	90	48	10	10	2	0	0	0	0	68.63	52.14	38.44	43.21	4.23	.60
2	19	26	152	98	72	18	3	1	0	0	0	0	66.70	52.04	39.36	44.15	5.05	.72
2	20	24	152	112	50	16	1	0	0	0	0	0	61.01	43.08	38.05	41.85	3.79	.54
2	21	20	160	96	42	8	5	0	0	0	0	0	61.20	47.44	36.07	40.62	3.41	.49
2	22	28	138	98	38	8	4	0	0	0	0	0	59.41	46.33	36.55	40.28	3.03	.44
2	23	34	136	66	42	6	0	0	0	0	0	0	56.56	44.56	35.53	38.94	2.59	.37
2	24	32	134	58	32	3	2	0	0	0	0	0	60.73	45.15	33.47	38.14	2.34	.33
2	25	26	88	58	28	4	0	2	0	0	0	0	60.77	45.96	35.53	39.46	2.04	.29
2	26	18	82	44	18	2	0	0	0	0	0	0	52.47	42.06	33.72	36.36	1.15	.16
2	27	14	49	24	4	1	0	0	0	0	0	0	47.33	38.88	31.76	34.28	.52	.07
2	28	14	35	17	8	2	0	0	0	0	0	0	57.29	42.75	32.32	36.18	.57	.08
2	29	7	17	5	0	0	0	0	0	0	0	0	47.23	36.58	29.16	31.81	.15	.02

TABLE B-5. TRIAL 1-6. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
2	30	3	17	8	0	0	0	0	0	0	0	0	41.18	34.02	29.16	30.75	.12	.02
2	31	8	17	0	0	0	0	0	0	0	0	0	32.47	30.07	27.16	28.03	.06	.01
2	32	3	11	2	0	0	0	0	0	0	0	0	34.70	31.65	28.39	29.46	.05	.01
2	33	3	15	0	0	0	0	0	0	0	0	0	28.84	28.32	27.46	27.61	.04	.01
2	34	1	5	0	0	0	0	0	0	0	0	0	23.84	28.32	27.46	27.61	.01	.00
2	35	3	7	1	0	0	0	0	0	0	0	0	33.17	30.11	26.73	27.80	.03	.00
											OVERALL		69.35	51.61	36.56	42.02	2.65	.38
											TOTAL		71.75	53.81	38.44	43.82	4.29	.61

TABLE B-7. TRIAL 1-7. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
1	8	72	288	232	216	40	16	8	0	0	0	0	67.22	54.41	43.40	46.24	13.43	1.92
1	9	55	134	144	44	20	4	0	0	0	0	0	61.52	46.26	39.00	41.10	4.32	.62
1	10	12	24	32	22	8	5	2	0	0	0	0	85.54	61.94	47.51	51.12	2.45	.35
1	11	6	34	30	12	3	4	2	2	0	0	0	93.70	62.40	42.33	48.90	2.32	.33
1	12	42	65	112	40	16	4	4	0	0	0	0	68.89	52.44	41.26	43.51	4.22	.60
1	14	11	56	46	21	6	4	0	0	0	0	0	65.92	51.01	39.56	43.34	1.83	.26
1	15	10	27	21	17	3	0	0	0	0	0	0	61.62	43.77	39.33	42.18	.87	.12
1	16	3	25	19	11	4	1	0	0	0	0	0	65.86	50.50	38.58	42.66	.84	.12
1	17	0	1	1	1	1	0	0	0	0	0	0	75.58	61.83	55.17	55.67	.09	.01
1	18	1	5	5	2	0	0	0	0	1	0	0	154.94	71.45	41.16	48.94	.49	.07
1	19	0	3	3	1	1	0	0	0	0	0	0	69.75	53.15	43.50	46.93	.11	.02
1	20	1	0	0	2	0	0	0	0	0	0	0	63.97	56.24	59.61	48.45	.05	.01
1	21	1	2	5	3	1	0	0	0	0	0	0	63.92	54.21	48.17	48.70	.18	.03
1	22	1	5	6	1	1	0	0	0	0	0	0	61.90	50.76	43.50	45.02	.20	.03
1	23	1	8	3	2	0	0	0	0	0	0	0	55.32	42.15	30.41	37.37	.10	.01
											OVERALL		67.95	53.17	41.17	44.42	.77	.11
2	7	54	113	128	64	16	14	4	2	0	0	0	74.87	55.65	41.76	45.10	6.53	.93
2	8	176	536	592	256	40	24	0	8	0	0	0	63.07	50.51	40.74	42.76	20.11	2.37
2	9	339	720	848	288	56	32	16	0	0	0	0	64.73	50.19	39.97	42.03	28.25	4.03
2	10	216	696	784	248	40	0	0	0	0	0	0	53.93	45.48	33.45	40.40	17.85	2.55
2	11	196	448	448	24	12	16	4	0	0	0	0	53.93	45.00	36.14	38.09	10.52	1.50
2	12	36	136	152	76	20	4	0	0	0	0	0	60.24	48.51	39.96	41.93	4.19	.60
2	13	34	28	114	24	8	0	0	0	0	0	0	52.68	45.25	39.50	39.97	2.37	.34
2	14	32	35	86	26	6	4	0	0	0	0	0	60.52	47.74	38.07	40.58	2.54	.36
2	15	28	64	106	24	8	4	2	0	0	0	0	63.03	50.72	41.95	43.06	2.94	.42
2	16	0	1	4	2	0	0	0	0	0	0	0	56.76	51.59	38.60	49.25	.09	.01
2	17	2	7	6	2	0	0	0	0	0	0	0	51.23	42.79	37.45	38.36	.13	.02
2	18	0	2	5	1	0	0	0	0	0	0	0	57.78	51.35	48.17	48.53	.13	.02
2	19	0	3	1	1	0	0	0	0	0	0	0	57.99	44.64	34.82	40.01	.04	.01
2	20	1	7	3	1	0	0	0	0	0	0	0	43.58	33.83	32.30	35.77	.07	.01
2	21	0	3	3	0	1	0	0	0	0	0	0	66.90	54.61	46.41	48.35	.14	.02
2	22	0	6	7	4	1	0	0	0	0	0	0	61.32	43.93	42.66	43.39	.24	.03
2	23	0	10	8	6	0	0	0	0	0	0	0	58.03	48.05	42.04	43.99	.25	.04
2	24	2	5	7	4	0	1	0	0	0	0	0	64.73	51.48	40.16	43.44	.29	.04
2	25	4	5	13	3	1	0	0	0	0	0	0	53.64	46.02	40.35	40.56	.28	.04
2	26	4	12	7	2	4	0	0	0	0	0	0	75.56	50.74	35.53	41.56	.35	.05
2	27	2	7	11	3	2	1	0	0	0	0	0	67.44	56.34	48.01	49.47	.53	.08
2	28	4	14	19	6	0	0	0	0	0	0	0	52.41	50.38	41.91	43.48	.57	.08
2	29	4	18	13	9	0	0	0	0	0	0	0	61.41	48.66	39.01	42.43	.51	.07
2	30	3	14	19	5	2	0	0	0	1	0	0	84.47	53.20	42.27	45.38	.83	.12
2	31	1	13	9	2	2	0	1	0	0	0	0	81.20	54.71	37.60	44.11	.44	.06
2	32	4	13	12	0	2	0	0	0	0	0	0	56.09	46.00	37.01	39.61	.31	.04
2	33	2	12	6	3	1	1	0	0	0	0	0	74.61	50.16	34.83	40.90	.29	.04
2	34	1	10	10	5	1	0	0	0	0	0	0	59.14	43.91	42.04	43.35	.30	.04
2	35	2	3	6	3	1	0	0	0	0	0	0	59.41	46.51	36.60	40.12	.18	.03

TABLE B-7. TRIAL 1-7. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
2	36	1	9	4	4	1	0	0	0	0	0	0	63.26	49.17	36.72	42.63	.22	.03
2	37	0	8	8	2	1	0	0	0	0	0	0	56.16	48.03	40.94	43.24	.20	.03
2	38	0	7	6	1	2	1	0	0	0	0	0	31.64	57.17	42.04	43.05	.30	.04
2	39	1	9	3	0	0	0	0	0	0	0	0	79.48	34.77	31.05	32.66	.05	.01
											OVERALL		62.66	49.56	39.72	42.06	.63	.10
3	8	43	90	70	15	6	0	2	1	0	0	0	63.33	46.73	34.07	37.58	2.22	.32
3	9	42	154	138	49	20	5	0	0	0	0	0	63.40	49.04	38.56	41.78	4.53	.65
3	10	56	278	304	136	16	8	0	0	0	0	0	58.75	48.59	41.46	42.95	8.73	1.25
3	11	72	392	328	72	32	8	0	0	0	0	0	59.57	46.14	37.14	40.38	8.43	1.21
3	12	32	104	116	44	16	4	0	0	0	0	0	62.70	49.88	40.38	43.00	3.75	.54
3	13	72	21[illegible]	200	72	8	0	0	0	0	0	0	53.92	44.43	37.34	39.18	4.76	.68
3	14	46	172	140	34	8	4	0	0	0	0	0	54.24	44.84	36.08	38.78	3.48	.50
3	15	14	48	33	14	1	1	0	0	0	0	0	56.57	44.75	35.36	38.61	.95	.14
3	16	9	47	31	13	0	0	1	0	0	0	0	56.97	45.57	35.67	39.11	.91	.13
3	17	2	14	20	5	2	0	0	0	0	0	0	55.29	43.28	42.47	43.45	.46	.07
3	18	5	13	11	3	2	2	0	0	0	0	0	79.94	53.16	37.66	42.84	.52	.07
3	19	3	7	7	5	2	0	0	0	0	0	0	65.15	52.43	43.31	45.40	.34	.05
3	20	2	7	3	0	1	1	0	0	0	0	0	90.44	52.83	32.80	40.33	.20	.03
3	21	0	7	6	1	0	0	0	0	0	0	0	47.57	42.28	37.66	39.45	.10	.01
3	22	0	2	3	3	0	0	0	0	0	0	0	60.05	52.39	49.33	49.00	.11	.02
3	23	1	3	6	2	1	0	0	0	0	0	0	61.70	51.50	44.96	45.39	.17	.02
											OVERALL		58.97	47.39	38.24	40.90	.97	.14
											TOTAL		62.82	49.58	39.54	42.09	.74	.11

TABLE B-8. TRIAL 2-1. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION		RAW DATA TABULATION											DIAMETERS (MICROMETERS)				DEPOSITION DENSITY	
		SIZE CATEGORIES											MASS	MASS	NUMBER	NUMBER		
ROW	POS	1	2	3	4	5	6	7	8	9	10	11	MEDIAN	MEAN	MEDIAN	MEAN	MG/M**2	OZ/ACRE
4	1	0	10	5	2	0	0	0	0	0	0	0	51.00	42.44	35.11	38.76	.12	.02
4	2	1	7	2	3	0	0	0	0	0	0	0	59.66	45.01	34.02	39.31	.11	.02
4	3	0	3	2	1	0	0	0	0	0	0	0	54.41	44.99	37.66	41.12	.05	.01
4	4	0	3	2	0	0	0	0	0	0	0	0	43.02	38.35	34.83	36.50	.03	.00
4	5	0	5	3	2	0	0	0	0	0	0	0	56.73	45.87	37.66	41.70	.09	.01
4	6	2	8	3	2	0	0	0	0	0	0	0	55.23	41.26	32.35	36.01	.10	.01
4	7	3	7	4	2	0	0	0	0	0	0	0	53.53	41.36	32.80	35.88	.11	.02
4	8	4	3	1	2	1	0	0	0	0	0	0	57.78	44.54	29.16	35.19	.14	.02
4	9	7	15	6	3	0	0	0	0	0	0	0	51.65	36.95	30.29	33.47	.18	.02
4	10	7	12	9	2	0	0	1	0	0	0	0	71.21	43.25	32.70	36.88	.33	.05
4	11	3	16	12	2	0	0	0	0	0	0	0	47.09	40.44	35.00	36.82	.21	.03
4	12	3	4	4	3	0	0	0	0	0	0	0	58.16	45.51	37.66	39.22	.13	.02
4	13	1	2	4	0	0	0	0	0	0	0	0	45.18	40.47	39.85	37.59	.04	.01
4	14	1	9	4	2	0	0	0	0	0	0	0	52.60	41.90	33.38	37.48	.11	.02
4	15	4	10	10	1	0	0	0	0	0	0	0	46.26	39.69	35.11	35.84	.15	.02
4	16	4	9	8	0	0	0	0	0	0	0	0	43.65	37.06	32.94	33.76	.10	.01
4	17	4	6	2	2	0	0	0	0	0	0	0	56.78	39.17	29.16	32.97	.09	.01
4	18	3	6	5	2	0	0	0	0	0	0	0	52.56	42.28	34.83	36.94	.12	.02
4	19	7	13	11	1	0	0	0	0	0	0	0	45.54	36.01	32.43	33.84	.17	.02
4	20	6	15	16	2	0	0	0	0	0	0	0	46.84	40.23	35.53	36.32	.25	.04
4	21	3	8	5	0	0	0	0	0	0	0	0	42.11	33.04	25.98	28.91	.07	.01
4	22	2	12	2	1	1	0	0	0	0	0	0	64.88	42.13	30.58	35.02	.13	.02
4	23	3	5	7	0	0	0	1	0	0	0	0	113.69	47.36	28.10	33.46	.25	.04
4	24	4	9	6	1	0	0	0	0	0	0	0	46.53	38.37	31.99	33.99	.11	.02
4	25	1	4	1	1	0	0	0	0	0	0	0	56.94	40.82	31.29	35.25	.05	.01
4	26	2	5	6	3	0	0	0	0	0	0	0	55.64	45.37	40.58	40.95	.15	.02
4	27	5	16	11	2	0	0	0	0	0	0	0	47.07	39.47	33.41	35.36	.20	.03
4	28	10	27	12	4	0	0	0	0	0	0	0	48.56	38.55	31.05	33.76	.29	.04
4	29	23	45	23	5	0	0	0	0	0	0	0	46.41	37.17	30.09	32.50	.48	.07
4	30	23	46	18	6	0	0	0	0	0	0	0	47.68	37.07	29.35	32.08	.45	.06
4	31	12	48	62	12	2	0	0	0	0	0	0	50.53	44.39	39.92	40.14	1.14	.16
4	32	38	92	72	14	0	0	0	0	0	0	0	47.73	39.80	33.60	35.37	1.30	.19
4	33	16	41	15	4	0	0	0	0	0	0	0	45.85	36.64	29.78	32.21	.36	.05
4	34	10	31	17	7	0	0	0	0	0	0	0	46.05	38.14	31.90	34.06	.32	.05
4	35	4	14	9	7	0	0	0	0	0	0	0	50.30	41.18	34.02	36.56	.20	.03
4	36	18	31	21	5	0	0	0	0	0	0	0	49.22	39.33	31.63	34.11	.44	.06
4	3[illegible]	8	10	9	0	0	0	0	0	0	0	0	42.59	34.66	29.16	30.93	.11	.02
4	38	9	20	11	3	1	0	0	0	0	0	0	52.50	41.01	31.71	34.90	.29	.04
4	39	8	22	18	5	0	0	0	0	0	0	0	49.79	41.43	34.96	36.81	.36	.05
4	40	15	24	14	3	1	1	0	0	0	0	0	57.76	42.60	30.58	34.43	.43	.06
4	41	27	52	31	5	0	0	1	0	0	0	0	50.62	40.42	30.80	33.55	.73	.10
4	42	34	74	54	14	4	0	2	0	0	0	0	59.24	45.28	33.76	37.16	1.67	.23
4	43	23	52	28	5	1	1	0	0	0	0	0	50.75	40.32	31.12	34.06	.69	.10
4	44	30	66	42	12	4	0	0	0	0	0	0	53.60	42.15	32.77	35.91	1.10	.16
4	45	66	172	79	24	6	0	0	0	0	0	0	51.53	39.49	30.25	37.47	2.15	.31
4	46	31	41	26	8	1	0	0	0	0	0	0	51.18	39.39	29.99	33.22	.63	.09

TABLE B-8. TRIAL 2-1. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MC/M**2	OZ/ACRE
4	47	33	55	50	10	1	0	0	0	0	0	0	48.70	39.96	32.82	34.91	.57	.14
4	48	5	13	13	3	1	1	0	0	0	0	0	62.69	43.26	37.66	40.37	.39	.06
											OVERALL		50.92	40.33	32.24	34.97	.39	.05
5	1	3	3	3	0	0	0	0	0	0	0	0	39.95	33.57	29.16	30.63	.05	.01
5	2	3	16	8	4	2	0	0	0	0	0	0	62.90	47.40	35.53	40.75	.33	.05
5	3	6	12	5	1	0	0	0	0	0	0	0	45.03	35.97	29.19	31.51	.11	.02
5	4	2	12	7	2	1	0	0	0	0	0	0	55.93	44.52	34.83	38.66	.20	.03
5	5	3	3	2	2	0	0	0	0	0	0	0	59.07	43.54	31.39	36.19	.08	.01
5	6	1	13	11	1	0	0	0	0	0	0	0	45.77	40.51	36.35	37.73	.17	.02
5	7	1	9	6	3	0	0	0	0	0	0	0	54.34	44.23	36.72	39.85	.16	.02
5	8	3	11	6	2	0	0	0	0	0	0	0	49.64	40.32	33.02	35.74	.14	.02
5	9	4	11	4	3	0	0	0	0	0	0	0	56.04	40.93	31.48	35.19	.14	.02
5	10	1	5	2	1	1	0	0	0	0	0	0	71.23	43.73	34.26	40.53	.11	.02
5	11	1	12	7	0	0	0	0	0	0	0	0	42.47	37.22	33.41	35.02	.10	.01
5	12	0	5	3	2	0	0	0	0	0	0	0	56.28	44.33	36.24	40.61	.09	.01
5	13	1	6	6	0	0	0	0	0	0	0	0	44.08	39.02	36.24	36.57	.07	.01
5	14	0	7	5	1	0	0	0	0	0	0	0	47.30	41.90	36.45	38.39	.09	.01
5	15	1	7	5	1	0	0	0	0	0	0	0	47.72	40.95	35.23	37.33	.09	.01
5	16	5	13	3	4	0	0	0	0	0	0	0	58.42	41.04	30.47	34.73	.17	.02
5	17	6	8	3	3	0	0	0	0	0	0	0	57.95	40.59	29.16	33.62	.13	.02
5	18	5	15	5	3	0	1	0	0	0	0	0	65.01	45.50	31.43	36.46	.26	.04
5	19	21	21	13	2	0	0	0	0	0	0	0	45.90	37.38	30.78	32.90	.23	.03
5	20	5	27	13	2	2	0	0	0	0	0	0	52.33	42.23	32.34	36.47	.35	.05
5	21	3	13	9	5	1	0	0	0	0	0	0	58.87	43.09	31.99	36.19	.31	.04
5	22	5	10	6	7	1	0	0	0	1	1	0	166.32	73.37	35.11	47.13	1.13	.16
5	23	4	14	7	1	3	1	0	0	0	0	0	80.10	51.23	34.02	45.72	.39	.06
5	24	0	18	6	2	1	0	0	0	0	0	0	55.02	42.17	32.47	36.54	.21	.03
5	25	3	10	3	2	0	0	0	0	0	0	0	53.63	39.52	30.36	34.26	.11	.02
5	26	4	6	2	0	0	0	0	0	0	0	0	57.66	40.20	23.16	33.43	.09	.01
5	27	5	9	3	4	0	0	0	0	0	0	0	59.30	42.60	31.05	35.68	.16	.02
5	28	13	7	5	2	0	0	0	0	0	0	0	51.26	35.24	31.38	29.79	.12	.02
5	29	2	1	1	1	0	0	0	0	0	0	0	59.43	43.19	29.16	34.92	.04	.01
5	30	5	6	5	0	0	0	0	0	0	0	0	43.27	35.07	23.16	31.04	.07	.01
5	31	9	18	9	3	1	0	0	0	0	0	0	60.36	45.00	33.41	37.86	.39	.06
5	32	8	22	9	5	1	0	0	0	0	0	0	57.48	42.30	31.87	35.35	.33	.05
5	33	21	45	21	8	0	0	0	0	0	0	0	49.82	36.77	30.67	33.56	.53	.08
5	34	54	30	54	14	0	0	0	0	0	0	0	48.12	38.20	30.48	33.08	1.10	.16
5	35	78	106	70	14	6	0	0	0	0	0	0	50.20	39.10	30.04	33.09	1.73	.25
5	36	48	133	74	10	0	0	0	0	0	0	0	43.32	35.12	28.92	31.03	.95	.14
5	37	50	102	50	16	0	0	0	0	0	0	0	50.41	39.37	30.83	33.78	1.30	.18
5	38	31	35	48	15	0	0	0	0	0	0	0	50.95	40.33	32.32	35.05	1.13	.17
5	39	44	116	54	18	0	0	0	0	0	0	0	49.80	38.72	31.31	33.93	1.29	.18
5	40	12	17	14	3	0	0	0	0	0	0	0	53.07	41.55	33.16	35.57	.34	.05
5	41	14	29	15	3	0	0	0	0	0	0	0	52.55	40.72	30.92	34.24	.41	.06
5	42	10	45	25	5	1	0	0	0	0	0	0	43.15	33.11	31.64	34.13	.53	.08

TABLE B-8. TRIAL 2-1, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MC/M**2	OZ/ACRE
5	43	9	26	15	7	1	0	0	0	0	0	0	55.90	43.14	33.74	37.20	.45	.06
5	44	42	77	48	14	4	1	0	0	0	0	0	54.85	42.25	31.92	35.32	1.34	.19
5	45	80	126	96	20	0	0	0	0	0	0	0	47.79	38.71	31.55	33.73	1.80	.26
5	46	36	134	74	10	0	0	0	0	0	0	0	44.90	35.33	29.04	31.38	1.35	.19
5	47	4	5	5	3	0	0	0	0	0	0	0	56.67	44.04	35.96	37.79	.14	.02
5	48	9	21	9	3	1	1	0	0	0	0	0	64.67	44.47	31.19	35.74	.37	.05
											OVERALL		51.71	40.34	31.13	34.17	.44	.06
6	1	14	17	4	0	0	0	0	0	0	0	0	35.58	29.75	24.16	26.57	.09	.01
6	2	5	9	7	1	0	0	0	0	0	0	0	46.45	38.31	31.99	33.79	.12	.02
6	3	2	4	6	0	0	0	0	0	0	0	0	44.76	39.23	37.66	36.07	.07	.01
6	4	4	10	4	3	0	0	0	0	0	0	0	56.34	41.33	31.71	35.45	.14	.02
6	5	0	7	3	2	0	0	0	0	0	0	0	55.84	43.93	35.23	39.71	.10	.01
6	6	1	8	6	0	0	0	0	0	0	0	0	43.32	38.03	34.47	35.66	.09	.01
6	7	2	4	6	2	0	0	0	0	0	0	0	52.36	44.73	40.58	40.09	.12	.02
6	8	1	5	4	0	0	0	0	0	0	0	0	42.91	37.26	33.41	34.73	.05	.01
6	9	3	6	3	0	0	0	0	0	0	0	0	41.46	34.13	29.16	30.78	.05	.01
6	10	1	3	5	1	0	0	0	0	0	0	0	49.53	44.07	41.16	40.37	.08	.01
6	11	3	8	5	4	0	0	0	0	0	0	0	57.90	44.74	35.53	38.94	.17	.02
6	12	1	7	6	4	0	0	0	0	0	0	0	57.35	46.39	40.58	42.32	.19	.03
6	13	7	15	7	1	0	1	0	0	0	0	0	59.76	42.72	30.29	34.07	.23	.03
6	14	7	19	7	4	0	0	0	0	0	0	0	52.86	39.63	30.95	34.25	.22	.03
6	15	3	8	1	1	0	0	0	0	0	0	0	49.81	35.69	28.10	30.75	.06	.01
6	16	6	13	8	4	0	0	0	0	0	0	0	53.91	41.66	33.08	36.08	.21	.03
6	17	1	6	2	2	0	1	0	0	0	0	0	92.17	54.16	34.83	43.12	.18	.03
6	18	2	5	4	2	0	0	0	0	0	0	0	54.76	43.59	35.96	38.29	.10	.01
6	19	0	1	0	1	0	0	0	0	0	0	0	63.17	52.58	37.66	46.96	.03	.00
6	20	2	6	2	0	0	0	0	0	0	0	0	33.19	33.34	29.16	30.57	.04	.01
6	21	0	2	1	0	0	0	0	0	0	0	0	41.88	37.18	33.41	35.38	.01	.00
6	22	1	3	2	2	0	0	0	0	0	0	0	59.23	46.72	37.66	40.99	.08	.01
6	23	4	7	5	2	0	0	0	0	0	0	0	52.02	41.00	32.80	35.43	.12	.02
6	24	7	18	11	3	0	1	0	0	0	0	0	57.19	44.10	32.94	36.51	.33	.05
6	25	16	20	11	5	0	0	0	0	0	0	0	52.04	38.83	29.16	32.71	.29	.04
6	26	13	31	13	3	1	0	0	0	0	0	0	49.51	38.74	30.26	33.18	.34	.05
6	28	12	43	17	1	0	0	0	0	0	0	0	41.73	35.19	30.35	32.05	.30	.04
6	29	25	44	22	4	1	0	0	0	0	0	0	47.71	37.65	29.55	32.28	.49	.07
6	30	16	26	7	3	0	0	0	0	0	0	0	46.80	35.19	27.20	30.08	.22	.03
6	31	4	29	9	5	0	0	0	0	0	0	0	51.59	40.05	32.09	35.56	.29	.04
6	32	6	16	9	7	0	0	0	0	0	0	0	47.17	38.57	31.82	34.12	.18	.03
6	33	11	32	26	5	1	0	0	0	0	0	0	50.54	42.11	35.00	37.09	.54	.08
6	34	24	34	15	3	0	0	0	0	0	0	0	45.16	35.25	27.66	30.41	.32	.05
6	35	13	43	23	3	1	0	0	0	0	0	0	46.98	38.88	31.93	34.31	.47	.07
6	36	6	8	6	2	0	0	0	0	0	0	0	50.57	39.71	31.29	34.01	.13	.02
6	37	37	75	24	5	0	0	0	0	0	0	0	44.38	35.17	28.37	30.73	.59	.08
6	38	44	74	15	2	0	1	0	0	0	0	0	42.85	33.75	26.18	28.51	.50	.07
6	39	35	64	29	10	1	0	0	0	0	0	0	50.40	33.61	29.83	32.91	.76	.11

TABLE B-8. TRIAL 3-1. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MC/M**2	OZ/ACRE
6	40	56	69	35	7	1	0	0	0	0	0	0	47.19	36.32	27.56	30.76	.77	.11
6	41	62	162	84	20	4	0	0	0	0	0	0	43.43	33.59	31.57	34.34	1.97	.28
6	42	41	51	23	9	2	0	0	0	0	0	0	53.70	33.81	28.00	31.97	.70	.10
6	43	38	60	66	30	2	0	0	0	0	0	0	55.22	43.71	35.53	37.33	1.72	.25
6	44	82	140	32	20	0	0	0	0	0	0	0	49.66	35.85	27.34	30.41	1.21	.17
6	45	144	244	100	42	1	1	0	0	0	0	0	51.20	33.33	23.16	32.42	2.86	.41
6	46	124	204	80	26	2	0	0	0	0	0	0	48.56	37.00	28.50	31.51	2.11	.30
6	47	94	194	134	36	6	2	0	0	0	0	0	52.40	41.80	32.84	35.67	3.25	.46
6	48	30	106	52	28	8	0	0	0	0	0	0	55.50	44.73	33.81	38.13	1.92	.27
6	49	25	33	12	6	0	0	0	0	0	0	0	50.70	36.83	27.36	30.94	.36	.05
6	50	0	0	0	1	1	1	0	0	0	0	0	92.88	34.80	32.02	82.22	.17	.02
											OVERALL		51.13	39.31	30.73	33.44	.52	.07
											TOTAL		51.25	40.05	31.08	34.08	.45	.06

TABLE B-9. TRIAL 2-3, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION RCW	FCS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
4	30	0	1	1	0	0	0	0	0	0	0	0	44.15	35.99	37.66	38.20	.01	.00
4	31	0	1	2	0	1	0	0	0	0	0	0	78.25	58.05	46.41	51.29	.07	.01
4	32	1	0	0	2	0	0	0	0	0	0	0	63.97	56.24	59.61	48.45	.05	.01
4	33	0	6	1	2	0	0	0	0	0	0	0	59.70	44.41	33.41	39.27	.09	.01
4	34	2	4	4	2	0	0	0	0	0	0	0	55.29	44.40	37.66	38.99	.10	.01
4	35	1	2	4	1	0	0	0	0	0	0	0	50.87	44.98	42.04	40.91	.07	.01
4	36	0	2	8	0	0	0	0	0	0	0	0	45.85	44.23	44.23	43.27	.08	.01
4	37	2	2	2	3	0	0	0	0	0	0	0	51.08	43.00	42.04	42.15	.10	.01
4	38	2	9	6	5	1	0	0	0	0	0	0	62.20	49.72	40.58	43.40	.26	.04
4	39	2	3	2	0	1	0	0	0	0	0	0	77.23	47.27	31.99	37.33	.08	.01
4	40	3	8	4	4	0	0	0	0	0	0	0	58.75	44.63	34.47	38.54	.16	.02
4	41	3	6	5	1	0	0	0	0	0	0	0	49.00	39.79	33.41	35.13	.09	.01
4	42	2	8	7	0	0	0	0	0	0	0	0	43.70	37.98	34.47	35.21	.09	.01
4	43	7	18	10	5	0	0	0	0	0	0	0	53.43	41.43	32.94	36.04	.27	.04
4	44	7	20	9	1	1	0	0	0	0	0	0	48.86	39.22	30.86	33.68	.22	.03
4	45	5	8	7	1	1	0	0	0	0	0	0	53.59	43.12	33.41	36.17	.17	.02
4	46	3	7	5	3	0	1	0	0	0	0	0	67.48	50.94	36.45	41.34	.24	.03
4	47	3	16	15	3	0	0	0	0	0	0	0	49.47	42.06	37.13	38.36	.26	.04
4	48	2	12	11	5	1	0	0	0	0	0	0	58.08	47.48	40.05	42.16	.32	.05
4	49	3	9	4	4	0	0	0	0	0	0	0	58.53	44.10	33.98	38.10	.16	.02
4	50	3	11	9	6	1	0	0	0	0	0	0	60.33	48.19	39.60	42.17	.32	.05
4	51	36	110	94	26	2	0	0	0	0	0	0	50.92	42.52	35.81	37.69	1.97	.28
4	52	15	34	41	13	0	0	0	0	0	0	0	51.61	43.66	38.73	38.96	.83	.12
4	53	32	94	58	14	0	0	0	0	0	0	0	48.01	33.52	32.78	35.07	1.17	.17
4	54	136	304	216	96	8	0	0	0	0	0	0	54.85	43.00	34.31	37.17	5.78	.82
4	55	288	512	448	160	0	16	0	0	0	0	0	54.81	43.71	34.74	37.15	11.37	1.62
4	56	208	552	392	192	16	8	0	0	0	0	0	57.33	44.81	35.32	38.51	11.77	1.68
4	57	4	5	5	2	0	0	0	0	0	0	0	52.92	42.03	34.26	36.15	.11	.02
4	58	1	2	3	2	0	0	0	0	0	0	0	60.00	50.45	46.41	45.44	.11	.02
4	59	1	1	0	3	0	0	0	0	0	0	0	56.88	53.70	47.57	47.20	.14	.02
4	60	1	7	1	2	0	1	0	0	0	0	0	92.86	53.44	32.80	41.71	.18	.02
4	61	2	9	2	1	0	0	0	0	0	0	0	47.19	37.08	30.11	32.79	.07	.01
4	62	1	2	3	1	0	0	0	0	0	0	0	52.36	44.73	40.58	40.09	.08	.01
4	63	1	4	4	1	0	1	0	0	0	0	0	93.21	54.02	39.85	44.29	.17	.02
4	64	1	3	2	3	0	0	0	0	0	0	0	60.84	45.33	42.04	43.56	.10	.01
4	65	1	5	3	1	0	0	0	0	0	0	0	50.09	41.32	34.26	36.38	.07	.01
4	66	1	3	8	1	0	1	0	0	0	0	0	67.94	53.74	44.23	46.00	.21	.03
4	67	1	5	4	2	0	0	0	0	0	0	0	57.98	45.84	39.85	41.31	.13	.02
4	68	1	1	2	1	0	0	0	0	0	0	0	56.16	46.38	42.04	40.85	.05	.01
4	69	1	5	1	1	0	0	0	0	0	0	0	56.06	33.75	30.86	34.56	.05	.01
4	70	1	2	3	2	0	0	0	0	0	0	0	57.97	48.11	43.50	43.10	.09	.01
4	71	2	5	5	1	0	0	0	0	0	0	0	49.54	41.27	35.96	36.93	.09	.01
4	72	0	1	1	2	0	0	0	0	0	0	0	61.91	54.76	55.17	51.19	.06	.01
4	73	2	4	6	1	0	0	0	0	0	0	0	49.56	42.37	33.12	38.24	.09	.01
4	74	1	3	1	1	0	0	0	0	0	0	0	57.83	42.10	31.99	36.17	.04	.01
4	75	0	4	4	1	0	0	0	0	0	0	0	49.85	44.18	33.95	41.08	.07	.01

TABLE B-9. TRIAL 2-3. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
4	76	1	1	3	1	0	0	0	0	0	0	0	53.11	46.43	43.50	41.82	.06	.01
4	77	2	1	2	0	0	0	0	0	0	0	0	60.03	47.87	42.04	40.77	.07	.01
4	78	1	3	2	0	0	0	0	0	0	0	0	42.40	36.30	31.99	33.25	.03	.00
4	79	1	1	2	0	0	0	0	0	0	0	0	45.07	36.84	37.66	35.01	.02	.00
4	80	0	1	1	1	0	0	0	0	0	0	0	59.76	50.76	46.41	46.36	.04	.01
4	81	2	2	2	0	0	0	0	0	0	0	0	43.73	35.37	29.16	31.13	.07	.00
4	82	0	0	3	1	0	0	0	0	0	0	0	54.01	52.21	49.33	51.04	.05	.01
4	83	1	2	3	2	0	0	0	0	0	0	0	57.97	48.11	43.50	43.10	.05	.01
4	84	0	0	3	0	0	0	0	0	0	0	0	46.41	46.66	46.41	46.66	.03	.00
4	85	0	1	2	0	0	0	0	0	0	0	0	45.28	42.45	42.04	41.02	.02	.00
4	86	1	0	2	1	0	0	0	0	0	0	0	57.06	49.07	46.41	43.63	.05	.01
4	87	2	0	3	0	0	0	0	0	0	0	0	46.13	39.77	40.58	34.80	.03	.00
4	88	0	2	2	0	0	0	0	0	0	0	0	44.15	33.99	37.66	38.20	.02	.00
4	89	0	3	1	2	0	0	0	0	0	0	0	61.02	49.08	37.66	44.04	.07	.01
4	90	0	0	1	0	1	0	0	0	0	0	0	90.35	63.92	55.17	64.37	.06	.01
4	91	2	3	0	1	0	0	0	0	0	0	0	61.27	38.90	26.33	31.23	.03	.00
4	92	0	1	1	1	0	0	0	0	0	0	0	59.76	50.76	46.41	46.86	.04	.01
4	93	2	2	0	1	0	0	0	0	0	0	0	61.96	40.28	24.91	31.53	.03	.00
4	94	1	5	1	0	0	0	0	0	0	0	0	35.41	32.39	29.16	30.33	.02	.00
4	95	0	1	3	1	0	0	0	0	0	0	0	53.25	49.20	46.41	46.78	.06	.01
4	96	0	2	2	0	0	0	0	0	0	0	0	44.15	39.99	37.66	38.20	.02	.00
4	97	1	2	3	0	0	0	0	0	0	0	0	44.76	39.23	37.66	36.07	.03	.00
4	98	0	1	1	0	0	0	0	0	0	0	0	44.15	39.99	37.66	38.20	.01	.00
4	99	0	2	2	0	0	0	0	0	0	0	0	44.15	39.99	37.66	38.20	.02	.00
4	100	0	0	1	1	0	0	0	0	0	0	0	60.64	56.77	55.17	55.42	.03	.00
4	101	0	3	0	1	0	0	0	0	0	0	0	61.40	44.11	31.95	38.35	.03	.00
4	102	0	3	1	1	0	0	0	0	0	0	0	57.99	44.64	34.83	40.01	.04	.01
4	103	0	1	1	0	0	0	0	0	0	0	0	44.15	39.99	37.66	38.20	.01	.00
4	104	1	3	2	0	0	0	0	0	0	0	0	42.80	36.30	31.99	33.25	.03	.00
4	105	0	0	1	0	0	0	0	0	0	0	0	46.41	46.66	46.41	46.66	.01	.00
													55.25	43.93	35.20	37.34	.51	.07
5	28	0	0	1	1	0	0	0	0	0	0	0	58.87	47.12	37.66	42.58	.04	.01
5	29	0	2	0	1	1	0	0	0	0	0	0	76.82	50.14	37.66	51.43	.03	.01
5	30	0	0	2	0	0	0	0	0	0	0	0	46.41	46.66	46.41	46.66	.03	.00
5	31	0	1	0	2	0	0	0	0	0	0	0	63.61	56.98	59.51	52.70	.05	.01
5	32	0	6	4	0	0	0	0	0	0	0	0	43.02	38.35	34.27	36.50	.05	.01
5	33	0	5	2	1	0	0	0	0	0	0	0	52.14	42.15	34.26	39.27	.06	.01
5	34	0	2	2	1	0	0	0	0	0	0	0	55.46	47.07	42.04	43.39	.05	.01
5	35	1	3	1	0	0	0	0	0	0	0	0	39.19	33.34	29.16	30.57	.02	.00
5	36	0	5	2	0	1	0	0	0	0	0	0	76.53	48.05	34.26	40.51	.08	.01
5	37	4	23	17	1	1	0	0	0	0	0	0	46.59	33.39	33.56	35.36	.32	.05
5	38	3	13	7	1	0	0	0	0	0	0	0	45.28	38.14	32.43	34.51	.13	.02
5	39	7	26	9	2	1	0	0	0	0	0	0	49.90	33.22	30.30	33.93	.26	.04
5	40	10	22	14	7	0	0	0	0	0	0	0	47.43	38.71	31.87	34.08	.27	.04
5	41	2	10	4	1	0	0	0	0	0	0	0	46.24	33.14	31.71	34.24	.03	.01

TABLE B-9. TRIAL 2-3, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
5	42	3	13	10	4	0	0	0	0	0	0	0	52.46	43.27	36.35	38.70	.23	.03
5	43	3	8	3	0	0	0	0	0	0	0	0	39.95	33.57	29.16	30.63	.05	.01
5	44	11	16	11	1	0	0	0	0	0	0	0	44.77	36.24	29.69	31.80	.18	.03
5	45	13	99	36	5	1	0	0	0	0	0	0	45.08	37.59	31.36	33.68	.75	.11
5	46	15	39	25	2	0	0	0	0	0	0	0	44.45	37.19	31.76	33.45	.40	.06
5	47	15	41	16	3	0	0	0	0	0	0	0	44.48	36.24	23.99	32.18	.34	.05
5	48	14	36	18	6	0	0	0	0	0	0	0	43.15	39.12	31.52	34.23	.42	.06
5	49	18	50	27	5	1	0	0	0	0	0	0	47.92	39.06	31.71	34.21	.53	.08
5	50	2	18	10	0	0	0	0	0	0	0	0	42.25	36.83	32.94	34.53	.14	.02
5	51	16	53	13	3	1	0	0	0	0	0	0	45.58	36.37	29.32	31.73	.40	.06
5	52	96	160	106	30	2	0	0	0	0	0	0	49.96	39.61	31.39	34.07	2.34	.73
5	53	496	1328	784	224	16	0	0	0	0	0	0	43.79	40.20	32.54	35.19	17.70	2.53
5	54	33	98	24	13	1	0	0	0	0	0	0	55.42	39.21	30.03	33.52	1.00	.14
5	55	1	5	5	1	0	0	0	0	0	0	0	43.62	42.31	37.66	38.60	.09	.01
5	56	1	3	3	0	0	0	0	0	0	0	0	44.01	38.15	34.33	35.17	.04	.01
5	57	2	4	2	1	0	0	0	0	0	0	0	52.85	40.15	31.29	34.49	.06	.01
5	58	1	3	2	0	0	0	0	0	0	0	0	42.80	36.30	31.99	33.25	.03	.00
5	59	1	3	2	1	0	0	0	0	0	0	0	54.20	42.87	34.93	37.67	.05	.01
5	60	1	1	4	0	0	0	0	0	0	0	0	45.74	41.78	42.04	38.90	.04	.01
5	61	0	3	4	0	0	0	0	0	0	0	0	44.72	41.08	39.85	39.41	.05	.01
5	62	2	6	3	0	1	0	0	0	0	0	0	74.27	44.05	31.99	36.21	.10	.01
5	63	0	0	0	2	0	0	0	0	0	0	0	64.05	64.18	64.05	64.18	.05	.01
5	64	1	2	2	0	0	0	0	0	0	0	0	43.94	37.36	33.41	33.96	.02	.00
5	65	0	1	2	0	0	0	0	0	0	0	0	45.28	42.45	42.04	41.02	.02	.00
5	66	0	1	4	0	0	0	0	0	0	0	0	45.65	44.23	44.23	43.27	.04	.01
5	67	0	2	3	0	0	0	0	0	0	0	0	44.90	41.50	40.56	39.89	.03	.00
5	68	0	3	2	0	0	0	0	0	0	0	0	43.02	33.35	34.83	36.50	.03	.00
5	69	0	1	1	1	0	0	0	0	0	0	0	59.76	50.76	46.41	46.66	.04	.01
5	70	0	3	0	1	0	0	0	0	0	0	0	61.40	44.11	31.99	38.35	.03	.00
5	71	0	2	2	1	0	0	0	0	0	0	0	55.46	47.03	42.04	43.39	.05	.01
5	72	0	1	0	1	0	0	0	0	0	0	0	63.17	52.58	37.66	46.96	.03	.00
5	73	0	1	1	0	0	0	0	0	0	0	0	61.91	54.76	55.17	51.19	.05	.01
5	74	1	1	1	0	0	0	0	0	0	0	0	43.73	35.37	29.16	31.13	.01	.00
5	75	1	4	0	2	0	0	0	0	0	0	0	62.21	45.02	31.29	37.76	.05	.01
5	76	0	1	3	0	0	0	0	0	0	0	0	45.66	43.58	43.50	42.43	.03	.00
5	77	0	2	2	1	0	0	0	0	0	0	0	55.46	47.03	42.04	43.39	.05	.01
5	78	0	4	2	0	0	0	0	0	0	0	0	41.88	37.18	33.41	35.38	.03	.00
5	79	1	1	1	0	0	0	0	0	0	0	0	43.73	35.37	29.16	31.13	.01	.00
5	80	0	2	1	1	0	0	0	0	0	0	0	58.87	47.12	37.66	42.58	.04	.01
5	81	0	1	0	0	0	0	0	0	0	0	0	63.61	56.98	59.61	52.70	.05	.01
5	82	0	2	1	0	0	0	0	0	0	0	0	41.88	37.18	33.41	35.38	.01	.00
5	83	0	0	2	0	0	0	0	0	0	0	0	46.41	46.66	46.41	46.66	.02	.00
5	84	0	1	2	3	0	0	0	0	0	0	0	61.48	55.44	55.17	52.60	.10	.01
5	85	1	2	3	1	0	0	0	0	0	0	0	52.36	44.73	40.53	40.09	.05	.01
5	86	0	0	0	0	1	0	0	0	0	0	0	82.02	82.09	82.02	82.09	.05	.01
5	87	1	2	2	0	0	0	0	0	0	0	0	43.94	37.38	33.41	33.36	.02	.00

TABLE B-9. TRIAL 2-3. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION — SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
5	88	0	2	1	0	0	0	0	0	0	0	0	41.88	37.18	33.41	35.38	.01	.00
5	89	1	1	0	1	1	0	0	0	0	0	0	77.17	53.64	37.66	48.25	.08	.01
5	90	0	1	1	1	0	0	0	0	0	0	0	59.76	50.76	46.41	46.86	.04	.01
5	91	0	0	1	2	0	0	0	0	0	0	0	62.35	53.45	59.61	58.34	.06	.01
5	92	1	0	0	0	1	0	0	0	0	0	0	81.94	65.35	20.66	49.54	.05	.01
5	93	0	0	0	1	0	0	0	0	0	0	0	64.05	64.18	64.05	64.18	.03	.00
5	94	0	0	1	0	0	0	0	0	0	0	0	46.41	46.66	46.41	46.66	.01	.00
5	96	0	0	0	1	0	0	0	0	0	0	0	64.05	64.18	64.05	64.18	.03	.00
												OVERALL	49.72	40.07	32.34	35.03	.41	.06
6	28	0	0	0	1	0	0	0	0	0	0	0	64.05	64.18	64.05	64.18	.03	.00
6	29	0	1	2	0	0	0	0	0	0	0	0	45.28	42.45	42.04	[illegible]	.02	.00
6	30	0	5	6	1	0	0	0	0	0	0	0	48.32	43.76	40.58	41.07	.10	.01
6	31	2	9	7	1	1	0	0	0	0	0	0	53.45	44.61	35.77	38.72	.17	.02
6	32	1	5	2	1	2	0	0	0	0	0	0	77.06	53.77	35.96	44.30	.16	.02
6	33	5	10	7	2	1	0	0	0	0	0	0	56.57	43.66	33.41	36.78	.20	.03
6	34	2	7	4	1	0	0	0	0	0	0	0	47.93	39.52	32.60	35.21	.08	.01
6	35	1	10	3	1	0	0	0	0	0	0	0	46.32	38.21	31.71	34.57	.08	.01
6	36	0	4	2	1	0	0	0	0	0	0	0	53.28	43.41	35.53	39.49	.05	.01
6	37	1	3	5	0	0	0	0	0	0	0	0	44.97	40.36	39.41	37.72	.06	.01
6	38	0	2	2	1	0	0	0	0	0	0	0	55.46	47.03	42.04	43.29	.05	.01
6	39	0	1	2	0	0	0	0	0	0	0	0	45.28	42.45	42.04	41.02	.02	.00
6	40	13	39	24	6	0	0	0	0	0	0	0	48.20	39.66	32.87	35.19	.49	.07
6	41	120	138	74	12	0	0	0	0	0	0	0	45.20	35.12	27.07	30.13	1.43	.20
6	42	17	29	18	0	0	0	0	0	0	0	0	42.36	34.70	29.45	31.11	.26	.04
6	43	86	156	60	16	0	0	0	0	0	0	0	45.99	36.01	23.62	31.22	1.42	.20
6	44	68	170	68	12	0	0	0	0	0	0	0	44.35	36.04	29.76	31.93	1.42	.20
6	45	130	224	80	9	2	0	0	0	0	0	0	42.95	34.27	27.64	29.31	1.71	.24
6	46	92	200	96	32	0	0	0	0	0	0	0	48.88	38.46	30.69	33.44	2.29	.33
6	47	106	239	98	10	0	0	0	0	0	0	0	42.78	35.00	29.23	31.18	1.85	.26
6	48	496	872	328	16	0	0	0	0	0	0	0	40.86	33.25	27.68	29.61	6.02	.86
6	49	36	146	70	30	2	0	0	0	0	0	0	52.60	41.41	33.00	36.30	1.93	.28
6	50	0	6	5	2	0	0	0	0	0	0	0	52.81	45.10	39.41	41.54	.11	.02
6	51	1	3	0	1	0	0	0	0	0	0	0	61.24	41.14	29.16	34.03	.03	.00
6	52	0	1	1	1	0	0	0	0	0	0	0	59.76	50.76	46.41	46.86	.04	.01
												OVERALL	44.62	35.74	23.98	31.29	.80	.11
												TOTAL	50.62	40.26	31.97	34.77	.51	.07

TABLE B-10. TRIAL 2-23. DPCP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
4	1	0	2	1	0	0	0	0	0	0	0	0	41.66	37.18	33.41	35.38	.01	.00
4	2	0	2	2	1	0	0	0	0	0	0	0	55.46	47.03	42.04	43.39	.05	.01
4	3	2	1	1	1	0	0	0	0	0	0	0	59.43	43.16	29.16	34.92	.04	.01
4	4	0	3	2	1	0	0	0	0	0	0	0	54.41	44.99	37.66	41.12	.05	.01
4	5	1	3	5	0	0	0	0	0	0	0	0	44.97	40.30	39.41	37.72	.06	.01
4	6	1	2	2	0	1	0	0	0	0	0	0	77.74	51.38	37.66	41.98	.08	.01
4	7	0	3	2	2	0	0	0	0	0	0	0	59.32	48.75	42.04	44.41	.08	.01
4	8	1	2	6	1	0	0	0	0	0	0	0	49.39	45.33	43.50	42.06	.09	.01
4	9	1	7	6	2	0	0	0	0	0	0	0	51.30	43.61	37.66	39.59	.13	.02
4	10	0	5	6	1	0	0	0	0	0	0	0	46.32	43.76	40.58	41.07	.10	.01
4	11	0	1	4	2	0	0	0	0	0	0	0	56.78	51.59	48.60	49.25	.09	.01
4	12	1	5	10	3	0	0	0	0	0	0	0	52.07	46.76	43.79	43.41	.19	.03
4	13	2	4	1	2	2	0	0	0	0	0	0	75.90	55.21	35.53	44.74	.13	.03
4	14	1	5	5	3	0	0	0	0	0	0	0	56.84	46.83	41.16	42.25	.14	.02
4	15	1	7	5	0	0	0	0	0	0	0	0	43.16	37.71	34.02	35.26	.07	.01
4	16	2	4	5	0	1	0	0	0	0	0	0	53.97	46.11	37.66	39.03	.11	.02
4	17	1	8	5	2	0	0	0	0	0	0	0	51.82	42.77	35.53	38.53	.12	.02
4	18	2	8	11	2	2	0	0	0	0	0	0	60.17	45.17	41.64	43.11	.28	.04
4	19	4	16	[illegible]	2	1	0	0	0	0	0	0	50.36	43.01	36.07	38.04	.28	.04
4	20	10	23	23	4	1	0	0	0	0	0	0	49.30	42.62	37.56	37.87	.49	.07
4	21	15	28	18	8	0	0	0	0	0	0	0	52.66	40.99	32.50	35.37	.45	.05
4	22	9	30	24	5	0	0	0	0	0	0	0	48.17	40.72	34.83	36.56	.44	.06
4	23	10	29	20	3	1	1	0	0	0	0	0	53.08	43.32	33.56	36.57	.50	.07
4	24	16	40	28	5	1	1	0	0	0	0	0	51.82	42.25	33.20	35.95	.66	.09
4	25	13	20	13	4	1	0	1	0	0	0	0	66.85	46.45	31.71	36.16	.50	.07
4	26	16	30	18	9	2	0	0	0	0	0	0	58.12	43.52	32.84	36.61	.59	.08
4	27	22	63	35	14	3	0	0	0	0	0	0	55.27	42.72	33.21	36.68	1.02	.15
4	28	26	50	41	9	1	0	0	0	0	0	0	49.55	40.66	33.41	35.44	.82	.12
4	29	15	27	23	9	2	1	0	0	0	0	0	60.31	46.25	35.46	38.61	.73	.10
4	30	32	68	56	18	0	0	0	0	0	0	0	50.75	41.45	34.41	36.40	1.18	.17
4	31	36	66	48	16	2	2	0	0	0	0	0	56.37	43.60	33.28	36.51	1.35	.19
4	32	16	25	25	11	2	1	0	0	0	0	0	60.52	46.99	36.98	39.41	.79	.11
4	33	34	124	74	13	4	0	0	0	0	0	0	50.54	41.32	33.41	36.23	1.71	.24
4	34	26	96	58	12	6	0	0	0	0	0	0	52.12	42.25	33.59	36.69	1.44	.21
4	35	50	32	46	15	4	0	0	0	0	0	0	53.99	40.87	30.32	34.29	1.29	.18
4	36	60	30	64	15	4	2	0	0	0	0	0	54.59	42.51	31.92	35.14	1.66	.24
4	37	24	60	33	15	2	0	0	0	0	0	0	55.22	42.27	32.94	36.26	.97	.14
4	38	39	30	40	25	2	0	0	0	0	0	0	57.27	42.55	32.35	36.15	1.37	.20
4	39	15	13	12	[illegible]	0	0	0	0	0	0	0	52.92	40.35	30.47	33.83	.28	.04
4	40	40	80	62	6	1	0	0	0	0	0	0	46.19	33.44	32.24	33.96	1.03	.15
4	41	50	84	54	16	0	0	0	0	0	0	0	52.48	41.00	31.39	34.44	1.36	.19
4	42	18	44	40	10	0	0	2	0	0	0	0	57.57	46.32	35.73	38.25	1.09	.15
4	43	34	72	56	10	6	0	0	0	0	0	0	55.97	44.38	33.88	37.04	1.50	.21
4	44	18	46	35	9	4	0	0	0	0	0	0	54.53	43.85	34.70	37.61	.90	.13
4	45	15	20	17	3	1	2	0	0	0	0	0	65.87	46.14	32.56	36.52	.54	.08
4	46	11	16	11	3	2	1	0	0	0	0	0	66.27	45.17	35.00	39.88	.56	.08

TABLE B-10. TRIAL 2-28. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
5	26	8	13	7	2	0	0	0	0	0	0	0	46.23	37.80	29.82	32.58	.15	.02
5	27	6	11	6	4	0	1	0	0	0	0	0	64.76	47.48	33.02	38.08	.29	.04
5	28	9	14	10	5	0	0	0	0	0	0	0	54.25	41.67	32.80	35.70	.26	.04
5	29	4	10	10	5	1	1	0	0	0	0	0	65.85	51.30	40.29	43.08	.40	.06
5	30	6	19	10	3	2	1	0	0	0	0	0	70.48	47.72	33.63	38.80	.43	.06
5	31	8	19	16	6	2	1	0	0	0	0	0	63.80	48.33	36.76	40.33	.56	.08
5	32	26	40	38	9	2	0	0	0	0	0	0	51.65	42.01	34.05	36.05	.82	.12
5	33	26	42	38	24	6	0	0	0	0	0	0	61.57	47.70	37.66	40.42	1.41	.20
5	34	19	44	43	13	0	0	1	0	0	0	0	54.18	44.74	36.50	38.26	1.03	.15
5	35	22	26	19	3	1	0	0	0	0	0	0	43.93	38.55	29.49	32.51	.39	.06
5	36	20	39	34	16	1	0	0	0	0	0	0	55.60	43.99	35.92	38.14	.90	.13
5	37	36	72	71	23	6	0	0	0	0	0	0	55.34	44.78	33.72	38.63	1.79	.25
5	38	29	43	36	6	2	0	0	0	0	0	0	49.81	40.35	32.13	34.49	.73	.10
5	39	32	54	64	28	4	2	0	0	0	0	0	59.44	47.50	39.30	40.55	1.89	.27
5	40	36	86	64	24	0	2	0	0	0	0	0	54.40	43.38	34.50	37.25	1.66	.24
5	41	52	58	72	18	4	2	0	0	0	0	0	55.05	44.45	35.61	37.15	1.73	.25
5	42	32	100	124	40	4	0	0	0	0	0	0	53.37	45.45	40.20	40.56	2.69	.38
5	43	25	43	32	21	3	0	0	0	0	0	0	59.50	45.55	35.29	38.63	1.12	.16
5	44	25	40	40	12	4	0	0	0	0	0	0	55.58	44.44	35.75	37.35	1.02	.14
5	45	50	80	86	32	2	0	0	0	0	0	0	53.65	43.55	36.60	37.84	1.97	.28
5	46	40	96	100	25	6	2	0	0	0	0	0	54.60	45.30	37.48	39.12	2.40	.34
5	47	54	104	106	20	4	2	0	0	0	0	0	51.72	43.15	35.53	37.13	2.23	.32
5	48	28	68	36	30	10	0	0	0	0	0	0	64.00	48.02	35.16	40.26	1.82	.26
5	49	86	140	150	68	6	0	0	0	0	0	0	56.14	44.86	37.54	38.85	3.89	.55
5	50	48	104	102	48	6	0	2	0	0	0	0	59.41	47.26	38.17	40.26	3.13	.45
5	51	68	88	62	38	8	2	0	0	0	0	0	61.85	45.73	33.22	37.45	2.43	.35
5	52	172	340	300	92	16	4	0	0	0	0	0	54.30	43.77	35.16	37.50	7.41	1.06
5	53	296	384	420	188	12	8	0	4	0	0	0	58.89	46.18	36.60	38.46	12.36	1.76
5	54	32	54	50	34	10	2	2	0	0	0	0	68.28	52.47	39.76	43.07	2.54	.36
5	55	56	102	88	34	6	2	0	0	0	0	0	57.58	44.99	35.33	38.08	2.51	.36
5	56	23	32	21	6	2	0	0	0	0	0	0	53.55	40.98	30.76	34.19	.55	.08
5	57	10	7	13	3	0	0	0	0	0	0	0	50.13	41.43	36.45	35.07	.22	.03
5	58	1	2	4	2	1	0	0	0	0	0	0	65.55	53.67	46.41	47.36	.15	.02
5	59	4	9	6	3	0	0	0	0	0	0	0	54.13	42.25	33.88	36.73	.16	.02
5	60	0	2	6	1	0	0	0	0	0	0	0	49.46	46.87	44.96	44.85	.09	.01
5	61	2	4	4	0	0	0	0	0	0	0	0	43.94	37.36	33.41	33.96	.05	.01
5	62	2	5	4	2	0	0	0	0	0	0	0	54.76	43.59	35.96	38.28	.10	.01
5	63	1	4	5	0	0	0	0	0	0	0	0	44.52	39.54	37.66	36.92	.06	.01
5	64	0	2	4	2	0	0	0	0	0	0	0	56.34	49.79	46.41	46.31	.09	.01
5	65	1	2	5	0	0	0	0	0	0	0	0	45.42	41.35	41.16	38.72	.05	.01
5	66	0	1	2	1	0	0	0	0	0	0	0	56.34	49.79	46.41	46.81	.05	.01
5	67	0	1	2	0	0	0	0	0	0	0	0	45.28	42.45	42.04	41.02	.02	.00
5	68	0	0	0	1	0	0	0	0	0	0	0	64.05	64.18	64.05	64.18	.03	.00
5	69	0	0	1	0	0	0	0	0	0	0	0	46.41	46.60	46.41	46.66	.01	.00
											OVERALL		57.17	45.24	36.20	38.41	.95	.14

TABLE B-10. TRIAL 2-2R. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	IDENTIFICATION POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
5	26	8	13	7	2	0	0	0	0	0	0	0	48.23	37.80	29.82	32.58	.15	.02
5	27	6	11	6	4	0	1	0	0	0	0	0	64.76	47.48	33.02	38.08	.29	.04
5	28	9	14	10	5	0	0	0	0	0	0	0	54.25	41.67	32.80	35.70	.26	.04
5	29	4	10	10	5	1	1	0	0	0	0	0	65.85	51.30	40.29	43.08	.40	.06
5	30	6	19	10	3	2	1	0	0	0	0	0	70.48	47.72	33.63	38.80	.43	.06
5	31	8	19	16	6	2	1	0	0	0	0	0	63.80	48.33	36.76	40.33	.56	.08
5	32	26	40	38	9	2	0	0	0	0	0	0	51.65	42.01	34.05	36.05	.82	.12
5	33	26	42	38	24	6	0	0	0	0	0	0	61.57	47.70	37.66	40.42	1.41	.20
5	34	19	44	43	13	0	0	1	0	0	0	0	54.18	44.74	36.50	38.26	1.07	.15
5	35	22	26	19	3	1	0	0	0	0	0	0	48.93	38.55	29.49	32.51	.39	.06
5	36	20	39	34	16	1	0	0	0	0	0	0	55.60	43.99	35.92	38.14	.90	.13
5	37	36	72	71	23	6	0	0	0	0	0	0	55.34	44.78	33.72	38.63	1.79	.25
5	38	29	43	36	6	2	0	0	0	0	0	0	49.81	40.35	32.13	34.49	.73	.10
5	39	32	54	64	28	4	2	0	0	0	0	0	59.44	47.50	39.30	40.55	1.89	.27
5	40	36	86	64	24	0	2	0	0	0	0	0	54.40	43.38	34.50	37.25	1.66	.24
5	41	52	58	72	18	4	2	0	0	0	0	0	55.05	44.45	35.61	37.15	1.73	.25
5	42	32	100	124	40	4	0	0	0	0	0	0	53.37	45.45	40.20	40.56	2.69	.38
5	43	25	43	32	21	3	0	0	0	0	0	0	59.50	45.55	35.29	38.63	1.12	.16
5	44	25	40	40	12	4	0	0	0	0	0	0	55.58	44.44	35.75	37.35	1.02	.14
5	45	50	80	86	32	2	0	0	0	0	0	0	53.65	43.55	36.60	37.84	1.97	.28
5	46	40	96	100	25	6	2	0	0	0	0	0	54.60	45.30	37.48	39.12	2.40	.34
5	47	54	104	106	20	4	2	0	0	0	0	0	51.72	43.15	35.53	37.13	2.27	.32
5	48	28	68	36	30	10	0	0	0	0	0	0	64.00	48.02	35.16	40.26	1.82	.26
5	49	86	140	150	68	6	0	0	0	0	0	0	56.14	44.86	37.54	38.85	3.89	.55
5	50	48	104	102	48	6	0	2	0	0	0	0	59.41	47.26	38.17	40.26	3.12	.45
5	51	68	88	62	38	8	2	0	0	0	0	0	61.85	45.73	33.22	37.45	2.43	.35
5	52	172	340	300	92	16	4	0	0	0	0	0	54.30	43.77	35.16	37.50	7.41	1.06
5	53	296	384	420	188	12	8	0	4	0	0	0	58.89	46.18	36.60	38.46	12.36	1.76
5	54	32	54	50	34	10	2	2	0	0	0	0	68.29	52.47	39.76	43.07	2.54	.36
5	55	56	102	88	34	6	2	0	0	0	0	0	57.58	44.99	35.37	38.08	2.51	.36
5	56	23	32	21	6	2	0	0	0	0	0	0	53.55	40.98	30.76	34.19	.55	.08
5	57	10	7	13	3	0	0	0	0	0	0	0	50.13	41.43	36.45	35.07	.22	.03
5	58	1	2	4	2	1	0	0	0	0	0	0	65.55	53.67	46.41	47.36	.15	.02
5	59	4	9	6	7	0	0	0	0	0	0	0	54.13	42.25	33.88	36.73	.16	.02
5	60	0	2	6	1	0	0	0	0	0	0	0	49.46	46.87	44.96	44.85	.09	.01
5	61	2	4	4	0	0	0	0	0	0	0	0	43.94	37.38	33.41	33.96	.05	.01
5	62	2	5	4	2	0	0	0	0	0	0	0	54.76	43.59	35.96	33.28	.10	.01
5	63	1	4	5	0	0	0	0	0	0	0	0	44.52	39.54	37.66	36.92	.06	.01
5	64	0	2	4	2	0	0	0	0	0	0	0	56.34	49.79	46.41	46.31	.09	.01
5	65	1	2	5	0	0	0	0	0	0	0	0	45.42	41.35	41.16	38.72	.05	.01
5	66	0	1	2	1	0	0	0	0	0	0	0	56.34	49.79	46.41	46.31	.05	.01
5	67	0	1	2	0	0	0	0	0	0	0	0	45.28	42.45	42.04	41.02	.02	.00
5	68	0	0	0	1	0	0	0	0	0	0	0	64.05	64.18	64.05	64.18	.03	.00
5	69	0	0	1	0	0	0	0	0	0	0	0	46.41	46.66	46.41	46.66	.01	.00
											OVERALL		57.17	45.24	36.20	38.41	.95	.14

TABLE B-10. TRIAL 2-2P, DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	POS	RAW DATA TABULATION SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	GZ/ACRE
6	10	0	0	0	1	0	0	0	0	0	0	0	64.05	64.18	64.05	64.18	.02	.00
6	11	0	1	0	2	0	0	0	0	0	0	0	63.61	56.98	59.61	52.70	.05	.01
6	12	0	2	1	1	0	0	0	0	0	0	0	58.37	47.12	37.66	42.58	.04	.01
6	13	0	0	1	0	1	0	0	0	0	0	0	80.35	66.92	55.17	54.37	.05	.01
6	14	0	1	1	1	0	0	0	0	0	0	0	59.76	50.76	46.41	46.36	.04	.01
6	15	1	1	1	1	0	0	0	0	0	0	0	55.59	46.31	37.66	39.39	.04	.01
6	16	0	2	4	0	0	0	0	0	0	0	0	45.23	42.45	42.04	41.02	.04	.01
6	17	1	3	2	2	0	0	0	0	0	0	0	59.23	46.72	37.66	40.99	.08	.01
6	18	1	1	2	1	0	0	0	0	0	0	0	56.18	46.38	42.04	40.35	.05	.01
6	19	1	1	2	2	0	0	0	0	0	0	0	45.07	38.84	37.66	35.01	.02	.00
6	20	0	1	3	0	0	0	0	0	0	0	0	45.66	43.58	43.50	42.43	.03	.00
6	21	1	3	4	0	0	0	0	0	0	0	0	44.61	39.42	37.66	36.61	.05	.01
6	22	1	4	2	2	0	0	0	0	0	0	0	58.73	45.40	35.53	39.74	.03	.01
6	23	0	3	2	2	0	0	0	0	0	0	0	59.32	48.75	42.04	44.41	.08	.01
6	24	2	3	3	2	0	0	0	0	0	0	0	57.44	45.18	37.66	39.15	.09	.01
6	25	3	6	4	2	0	0	0	0	0	0	0	54.09	41.95	33.41	36.29	.11	.02
6	26	2	6	6	3	0	0	0	0	0	0	0	55.35	45.20	39.12	40.29	.15	.02
6	27	3	8	2	0	1	0	0	0	0	0	0	74.95	41.23	29.16	33.16	.05	.01
6	28	1	4	1	0	0	0	0	0	0	0	0	36.93	32.30	29.16	30.43	.02	.00
6	29	1	3	6	2	0	0	0	0	0	0	0	52.81	46.70	43.50	42.68	.12	.02
6	30	2	8	6	1	0	0	0	0	0	0	0	47.05	40.07	34.47	36.24	.10	.01
6	31	3	10	8	2	1	0	0	0	0	0	0	55.08	44.90	35.96	36.84	.21	.03
6	32	9	21	11	8	2	0	0	0	0	0	0	61.50	45.91	34.02	38.59	.47	.07
6	33	12	25	31	3	0	1	0	0	0	0	0	53.12	44.95	38.51	39.06	.67	.10
6	34	8	24	24	6	0	0	0	0	0	0	0	49.70	42.31	36.95	37.98	.45	.06
6	35	8	28	20	5	0	1	0	0	0	0	0	57.13	43.61	34.62	37.47	.49	.07
6	36	11	18	23	6	4	0	0	0	0	0	0	60.41	47.54	39.18	40.46	.64	.09
6	37	17	34	22	13	2	1	0	0	0	0	0	61.23	46.18	34.41	38.49	.64	.12
6	38	10	40	36	13	1	0	0	0	0	0	0	53.33	44.39	37.66	39.56	.84	.12
6	39	20	45	30	7	4	1	0	0	0	0	0	58.75	44.46	33.32	36.97	.90	.13
6	40	40	41	21	11	3	0	0	0	0	0	0	53.71	40.97	28.13	33.03	.75	.11
6	41	44	65	30	16	3	1	0	0	0	0	0	59.22	42.11	29.95	34.20	1.14	.16
6	42	22	23	22	9	4	0	0	0	0	0	0	61.31	45.51	33.96	37.38	.77	.10
6	43	33	68	46	17	1	0	0	0	0	0	0	52.22	41.36	33.04	35.77	1.22	.16
6	44	25	37	32	15	2	0	0	0	0	0	0	56.80	43.94	34.67	37.34	.30	.13
6	45	49	63	37	10	2	1	1	0	0	0	0	57.32	41.71	29.41	33.35	1.17	.17
6	46	33	67	41	12	2	0	0	0	0	0	0	51.37	40.59	31.95	34.34	.93	.14
6	47	38	67	46	16	4	1	0	0	0	0	0	56.92	43.42	32.84	36.28	1.35	.19
6	48	66	82	126	30	4	0	0	0	0	0	0	51.66	43.54	38.49	37.96	2.43	.35
6	49	76	96	88	38	4	4	0	0	0	0	0	59.12	45.14	34.30	37.32	2.65	.38
6	50	140	176	136	52	8	4	0	0	0	0	0	53.85	43.51	34.96	36.73	4.54	.65
6	51	256	444	322	120	12	8	4	0	0	0	0	57.01	43.96	33.37	36.57	9.55	1.36
6	52	280	432	516	224	56	15	4	4	0	0	0	63.72	49.27	33.47	40.38	18.21	2.60
6	53	136	212	188	88	16	4	0	0	0	0	0	59.30	45.71	35.57	38.43	5.88	.84
6	54	112	204	168	72	4	0	0	0	0	0	0	54.28	42.90	34.66	37.07	4.23	.70

TABLE B-10. TRIAL 2-23. DROP DEPOSITION AND SUMMARY DATA

IDENTIFICATION ROW	PCS	RAW DATA TABULATION — SIZE CATEGORIES 1	2	3	4	5	6	7	8	9	10	11	DIAMETERS (MICROMETERS) MASS MEDIAN	MASS MEAN	NUMBER MEDIAN	NUMBER MEAN	DEPOSITION DENSITY MG/M**2	OZ/ACRE
6	55	68	128	134	46	0	0	0	0	0	0	0	51.86	42.80	36.60	37.68	2.82	.40
6	56	64	104	82	24	6	0	0	0	0	0	0	53.37	42.20	33.08	35.85	2.01	.29
6	57	17	49	39	10	2	0	0	0	0	0	0	51.67	42.66	35.06	37.36	.87	.12
6	58	17	36	37	13	3	1	0	0	0	0	0	58.58	46.70	37.90	39.88	1.04	.15
6	59	6	18	8	5	0	0	0	0	0	0	0	55.21	41.45	32.47	35.98	.25	.04
6	60	4	12	10	3	0	0	0	0	0	0	0	50.36	41.97	35.53	37.78	.21	.03
6	61	3	6	7	1	0	0	0	0	0	0	0	47.55	40.72	36.24	36.48	.11	.02
6	62	1	5	6	1	0	0	0	0	0	0	0	48.25	42.67	39.12	39.22	.10	.01
6	63	1	6	5	3	0	0	0	0	0	0	0	56.54	46.04	39.41	41.42	.14	.02
6	64	1	3	4	4	0	0	0	0	0	0	0	59.94	50.52	46.41	45.80	.15	.02
OVERALL													57.57	44.95	35.10	37.31	1.29	.18
TOTAL													58.31	45.66	35.89	38.30	1.10	.16

Table B-11. FP Data for Trial 1-5 (3-1) Project 000-029 (UN Spray)[a]

Station No.	FP Count U-Shaped Rotorods	FP Count H-Shaped Rotorods	Station No.	FP Count U-Shaped Rotorods	FP Count H-Shaped Rotorods
B-10	3540	1360	B-27	12	10
B-11	3860	1275	B-28	4	16
B-12	860	254	B-29	24	6
B-13	520	232	B-30	10	20
B-14	630	276	B-31	20	18
B-15	1400	732	B-32	32	28
B-16	0	rod missing	B-33	28	28
B-17	34	24	B-34	36	16
B-18	194	92	B-35	48	28
B-19	120	36	B-36	48	40
B-20	18	6	B-37	38	46
B-21	26	4	B-38	34	44
B-22	42	20	B-39	24	29
B-23	12	6	B-40	18	18
B-24	14	12	B-41	42	34
B-25	13	8	B-42	10	14
B-26	4	6	B-43	30	14

(continued)

Table B-11. FP Data for Trial 1-5 (3-1) Project 000-029 (UM Spray)[a] (concluded)

Station No.	FP Count U-Shaped Rotorods	FP Count H-Shaped Rotorods	Station No.	FP Count U-Shaped Rotorods	FP Count H-Shaped Rotorods
B-44	8	0	B-52	20	10
B-45	6	6	B-53	10	8
B-46	28	8	B-54	16	18
B-47	6	8	B-55	8	16
B-48	24	10	B-56	14	16
B-49	6	6	B-57	9	10
B-50	18	10	B-58	11	12
B-51	14	12	B-59	30	14

[a] The initial ratio was 4.03 grams FP per gallon No. 2 fuel oil.

The preflight sample was 0.7 grams FP per gallon of fuel oil for Tank 5, and 0.65 grams FP per gallon fuel oil for Tank 6.

The post-flight sample was 0.95 grams FP per gallon of fuel oil for Tank 5, and 1.6 grams FP per gallon of fuel oil for Tank 6.

APPENDIX C. DISTRIBUTION LIST

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